

IOWA STATE COLLEGE
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ABSTRACTS OF DOCTORAL DISSERTATIONS

ACCEPTED JULY 1, 1950 — JUNE 30, 1951

These abstracts are arranged in alphabetical order by names of the authors. The first page of each abstract carries also the serial number of the dissertation, the date of acceptance of the thesis by the Graduate College, the name of the chairman of the student's committee, the degrees held by the author, and the candidate's academic position and relationship (if any) to the several research institutes of Iowa State College.

The following summaries and indices may prove helpful to those interested in tabulations and to those who wish to examine groups of abstracts of theses in the same or related fields.

1. DOCTORAL DISSERTATIONS ACCEPTED JULY 1, 1950 - JUNE 30, 1951. 109.
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 - a. Institutions other than Iowa State College - 92.
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2. INDEX TO THESES BY DEPARTMENTS. Double indexing is used in those cases in which two departments are jointly responsible. The departments are arranged alphabetically. Under each department are listed alphabetically the names of the authors.

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3. INDEX TO THESES BY RESEARCH INSTITUTES THAT PROVIDED RESEARCH FACILITIES. A graduate school can function only where there are adequate opportunities for research. The existence on the campus of Iowa State College of six research institutes well integrated into the college programs is in large measure responsible for the growth of the graduate work. These institutes have frequently assumed the responsibility of providing the research facilities necessary for the doctoral candidates in their respective fields. It is obvious that these institutes carry on a significant fraction of their researches by use of workers who are in a sense apprentices in research. Under the name of each institute is given the total number of theses for which research facilities were afforded, and an alphabetical list of the authors of sponsored theses.

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PHYSIOLOGICAL CHANGES AND FREEZING INJURY IN MATURING MAIZE¹

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Department of Botany

The physiological changes in maturing corn kernels have been studied extensively. Not much work has been done to observe the effect of freezing on the same changes. An attempt was made here to find a relationship between the chemical changes and viability in frozen corn.

At different stages of maturity, ears of WF9x38-11 single cross field corn were snapped. A group of the snapped ears was tested for moisture and analyzed for chemical composition. A second group was held on wire racks to dry in the field as a control. A third and fourth group were mildly and severely frozen, respectively, in cold rooms before drying in the field.

Reducing sugars and sucrose were determined in 70 per cent alcohol extract by the ceric sulfate method. Nitrogen was determined in both the alcohol extract and the residue by the Kjeldahl method.

It was found that the kernels in frozen ears lost their moisture at a slower rate than the unfrozen when dried in the field with the husks on, but that they lost moisture faster than the unfrozen when dried without husks.

The moisture percentage in maturing kernels decreased gradually while the moisture percentage in the husks decreased slowly at first then rapidly later. The moisture percentage in the cobs decreased very slowly and the cobs contained more moisture than the kernels at all harvest periods.

The maximum dry weight of kernels was attained at 25 per cent moisture content in an early planting and the same dry weight was attained at 40 per cent moisture in a late planting of the same variety. In 1947 the maximum dry weight

per kernel was reached at 32 per cent moisture but in 1948 it was reached at 38 per cent moisture for the same hybrid. The moisture percentage at which maximum dry weight is reached is affected by varietal and seasonal differences.

The dry weight per kernel did not change during drying, but it decreased slightly in the early harvests with freezing.

Both reducing sugars and sucrose decreased in the kernels with maturation, the sucrose percentage being higher in all harvests. In the drying ears, sucrose decreased rapidly but reducing sugars decreased slowly. When ears were frozen before drying, the kernels contained less sucrose but more reducing sugars. Apparently the injury of the protoplasm by freezing resulted in an increased rate of sucrose hydrolysis.

During maturation the alcohol-soluble nitrogen and the total nitrogen percentages decreased while the insoluble nitrogen remained constant. With field drying, the alcohol-soluble nitrogen decreased, while both the insoluble and total nitrogen increased. The frozen ears, however, contained more alcohol-soluble, less insoluble, and the same percentage of total nitrogen as the unfrozen.

There is an indication that nonprotein nitrogen is translocated into the kernels during development where it is synthesized into zein, globulins, glutelins, and other proteins. When ears are snapped, some simple nitrogenous compounds are still translocated during drying and synthesized in the kernels. Freezing did not stop translocation but lessened, if it did not stop, transformation in the kernels.

Ability of corn kernels to germinate starts early in their life, but the more mature seeds produce more vigorous seedlings. Freezing decreases both germinability and viability of seed corn. Reduction of vigor in seedlings may be due either to the quantity of protoplasm and nutrients available in the seed or to the injury of protoplasm caused by freezing.

1 a. Chairman of Committee, W. E. Loomis, Professor, Dept. of Botany and Agricultural Experiment Station.

b. Doctoral Thesis No. 1130. Submitted December 11, 1950.

2 a. B.Sc., Fouad I University, Cairo, Egypt, 1940.

M.S., Iowa State College, Ames, Iowa, 1947.

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PREDICTION OF ACHIEVEMENT OF IOWA STATE COLLEGE ENGINEERING STUDENTS HAVING TRANSFERRED FROM OTHER INSTITUTIONS¹

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Department of Vocational Education

The purpose of this investigation was to characterize the entering undergraduate transfer student in engineering as to the nature of the college at which he began his college work and as to the extent of his college work completed before entering the Iowa State College. It was also the purpose of this study to predict the academic achievement in engineering of undergraduate students who transferred to the Iowa State College from other institutions of higher learning. For the purpose of this study, academic achievement was defined in terms of the tendency of transfer students to begin the fourth quarter at the Iowa State College while enrolled in an engineering curriculum, the tendency to begin the fourth quarter in engineering without a scholastic probationary record, the tendency to graduate in an engineering curriculum, and the tendency to graduate in engineering in the upper half of the class. Prediction of these measures of achievement was made on the basis of test scores compiled by the psychological testing program, and records maintained in the registrar's office, these variables being available prior to the date the transfer student began his work or early in his academic career at the Iowa State College.

A sample of 1,746 male transfer students was included in the study. The sample was delimited to those students who graduated from secondary schools located within the continental limits of the United States, and who, prior to enrolling at the Iowa State College, attended only those institutions of higher learning which met the same geographic restrictions. The sample was further delimited to those transfer students who entered various engineering curricula be-

tween the fall quarter of 1946 and the fall quarter of 1949, inclusive.

Information was obtained concerning the number of colleges attended, and the accreditation, control, length of program, type of program, size and geographic location of the first college ever attended by each student. It was found that most students only attended one college prior to enrolling in the Engineering Division. The first colleges most students attended were usually accredited by the American Association of Universities, were usually controlled by the state or by sectarian organizations, offered only a four-year program with liberal arts and teacher preparation curricula, very likely had enrollments of less than 500 students, and were located in Iowa.

Additional information was gathered concerning the curricula entered at the Iowa State College and the registrar's evaluation of the collegiate quarter-hour credits presented at the time of matriculation. More than one-half of the students presented less than 80 quarter-hour credits, whereas about the same per cent had less than 60 quarter-hour credits accepted. Inspection of the per cent of credits presented that were accepted revealed that only 36 per cent of the students had less than 80 per cent of their credits accepted.

Stratification of the sample into more homogeneous subgroups was made on the basis of veteran status and college status. The subgroups were the veteran students who first attended junior colleges, nonveteran students who first attended junior colleges, veteran students who first attended colleges other than junior colleges, and nonveteran students who first attended colleges other than junior colleges.

Prediction schemes were developed from a modified discriminant function technique and were computed for each of the four subgroups with respect to each of the four criteria of academic achievement. Six prediction variables

1 a. Chairman of Committee, James E. Wert, Professor, Dept. of Vocational Education and Agricultural Experiment Station.

b. Doctoral Thesis No. 1167. Submitted June 4, 1951.

2 a. B.A., Trinity College, Sioux City, Iowa, 1943.
M.S., Iowa State College, Ames, Iowa, 1949.

were considered. They were the linguistic and quantitative scores on the American Council on Education Psychological Examination; the high school grade-point averages; an English placement score which may have been either the United States Armed Forces Institute Test on Correctness and Effectiveness of Expression, College Level, or the English Placement Test for Iowa Universities and Colleges, Form J; the rating of the student's collegiate academic success prior to entering the Engineering Division; and the first quarter grade-point average at the Iowa State College.

Within subgroups biserial coefficients of correlation were computed for each criterion and each of the six prediction variables. The values ranged from .17 for the linguistic score to .61 for the first quarter grade-point average with respect to the tendency to begin the fourth quarter in engineering criterion; from .23 for the linguistic score to .76 for the first quarter grade-point average with respect to the tendency to begin the fourth quarter without scholastic probationary record criterion; from .19 for the linguistic score to .66 for the first quarter grade-point average with respect to the tendency to graduate in engineering criterion; and from .23 for the linguistic score to .73 for the first quarter grade-point average with respect to the tendency to graduate in engineering in the upper half of class criterion. All correlations were significantly different from zero. Subsequent calculations demonstrated that, when a combination of prediction variables was used in the discriminant function, the linguistic score could be dropped from the prediction scheme without incurring a serious loss in ability to predict academic success as measured by any of the criteria.

Discriminant functions which were adjusted so as to yield predictions in terms of probability of survival were found for five different combinations of the prediction variables. Separate prediction schemes for each criterion were developed for each of the four subgroups with every combination of the prediction variables. The combinations of prediction variables were the quantitative score and the high school grade-point average, the same two plus the English placement score, the foregoing three plus the academic rating of previous collegiate work, all five of the prediction variables simultaneously, and the first quarter grade-point average alone. The multiple biserial correlations

for the two, three, four, and five prediction variable discriminant functions were .34, .37, .40, and .62 respectively for the tendency to begin the fourth quarter in engineering criterion; .46, .47, .55, and .79 respectively for the tendency to begin the fourth quarter without scholastic probationary record criterion; .38, .40, .48, and .69 respectively for the tendency to graduate in engineering criterion; and .43, .46, .55 and .77 respectively for the tendency to graduate in engineering in the upper half of the class criterion. In every instance, the addition of a prediction variable caused an appreciable gain in ability to predict academic achievement in engineering as measured by any of the criteria.

To allow a counselor to predict by inspection the probability of survival for a transfer student, classified in the appropriate subgroup, in regard to any of the four criteria on the basis of designated prediction variables, probability of survival tables were constructed. These tables were developed from discriminant functions using the quantitative scores and the high school grade-point averages as prediction variables, and from discriminant functions using the first quarter grade-point averages as a prediction variable. The chances in 100 of survival with respect to a given criterion were predicted for each subgroup in the order of veteran students who first attended junior colleges, nonveteran students who first attended junior colleges, veteran students who first attended colleges other than junior colleges, and nonveteran students who first attended colleges other than junior colleges.

As the caliber of transfer student as measured by the two prediction variables changed from superior to average to inferior, the predicted chances in 100 of survival for the four subgroups changed appreciably. In the case of the tendency to begin the fourth quarter in engineering criterion, the predicted probabilities for the different types of students in the four subgroups were:

superior students:	67, 67, 78, 76
average students:	49, 48, 62, 59
inferior students:	26, 25, 38, 35

For the single prediction variable discriminant function, the predicted chances in 100 of survival for the same criterion were:

superior students:	82, 86, 88, 88
average students:	51, 58, 61, 62
inferior students:	22, 27, 31, 31

For the tendency to begin the fourth quarter in engineering without scholastic probationary record criterion, the two prediction variable discriminant functions yielded the following probabilities of survival:

superior students:	44, 34, 68, 50
average students:	24, 17, 46, 29
inferior students:	9, 5, 22, 11

The single variable prediction scheme for this criterion produced similar fluctuations for the various types of students.

superior students:	59, 56, 78, 66
average students:	25, 23, 45, 31
inferior students:	7, 6, 17, 10

When the two prediction variable discriminant functions for the graduation in engineering criterion were solved, the predicted chances in 100 of survival were:

superior students:	50, 35, 63, 40
average students:	31, 18, 43, 23
inferior students:	13, 6, 21, 8

The probabilities of survival for this criterion when predicted from the single variable scheme were:

superior students:	66, 58, 75, 62
average students:	32, 25, 42, 28
inferior students:	11, 7, 16, 9

With respect to the tendency to graduate in engineering in the upper half of the class, the two prediction variable discriminant functions yielded the following chances in 100 of survival:

superior students:	28, 18, 39, 28
average students:	15, 9, 23, 16
inferior students:	6, 3, 11, 6

When the single variable discriminant functions for the same criterion were solved, the predicted chances in 100 of survival for the various types of students were:

superior students:	39, 32, 48, 41
average students:	16, 12, 23, 17
inferior students:	5, 3, 8, 6

The probability of survival in each of the four criteria could to some extent be predicted at the time of the transfer student's matriculation from the Q-score, the high school grade-point average, the English placement score, and the I.S.C. rating. At the end of the first quarter at the Iowa State College, the probability of survival could be predicted from the first quarter grade-point average.

PREPARATION OF NITROGENOUS FERTILIZERS BY TREATMENT OF CELLULOSIC MATERIALS WITH AMMONIA¹

JOHN WESLEY ANDERSON²

Department of Chemical Engineering

An investigation was carried out to develop an economical process for making nitrogenous fertilizers from ammonia and cellulosic waste materials such as corn-cobs, cornstalks, and oat hulls. In this endeavor, two different methods were investigated.

One method was based on hydrolysis of the hemicelluloses in these materials with dilute solutions of mineral acids or salts followed by ammoniation with anhydrous ammonia of the hydrolysate. With corn-cobs, when 8.25 per cent sulfuric acid and

a liquid/solid ratio of 2.0 was used for hydrolysis, and ammoniation was carried out slightly above room temperature, a product was obtained containing 7.4 per cent total nitrogen of which 4.2 per cent was organic nitrogen (product A). With the same hydrolysis conditions and an ammoniation temperature of 249°C., a product was obtained containing 9.5 per cent nitrogen of which 56 per cent was organic nitrogen (product B). In product A, 86.4 per cent of the total nitrogen was water-soluble, and in product B only 17.6 per cent was water-soluble. Normal and concentrated superphosphates or dilute phosphoric acid in the hydrolysis step did not result in as much organic nitrogen as sulfuric acid.

The second method involved the ammoniation of the cellulosic materials with anhydrous ammonia. By this process, a product containing 4.6 per cent total nitro-

1 a. Chairman of Committee, G. L. Bridger, Professor, Dept. of Chemical Engineering, Engineering Experiment Station, Institute for Atomic Research.

b. Doctoral Thesis No. 1082. Submitted July 11, 1950.

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gen was obtained with corncobs at a temperature of 300°C. (product C). In this product, all the nitrogen was organic, and none of it was water-soluble.

Small-scale engineering equipment for producing product A was built and tested. Products were made which were essentially the same as those prepared on a laboratory scale.

An evaluation of products A, B, and C as fertilizer materials was made. Tests were made to determine chemical stability, hygroscopicity, and caking characteristics. These tests showed that products A, B, and C could be used in mixed fertilizers. Greenhouse plant-growth tests were carried out. Product A proved to be

better than Milorganite, a commercial nitrogen fertilizer made from sewage, and was almost as good as ammonium sulfate. Products B and C did not compare well with product A, ammonium sulfate, or Milorganite in the plant-growth tests; however, under different conditions of a longer growing season, these two products might be better.

A preliminary cost analysis indicated that product A might compete with ammonium sulfate and could easily undersell Milorganite.

It is recommended that further pilot plant work be carried out on the production of product A.

EFFECTS OF IMPLANTING PITUITARY GLANDS AND INJECTING AVIAN BLOOD SERUM EXTRACT INTO CHICKENS¹

ROBERT LAWSON BAILEY²

Department of Poultry Husbandry

In recent years many reports have been published about the anterior pituitary gland and its influence on the reproductive processes. Most of the research has been done on mammals and animals of the lower classes with only a small percentage being devoted to the domestic fowl. Considerable work has been done on gonadotropic hormones of extra-pituitary origin. These substances are obtained from the blood serum and the urine of pregnant women and domestic animals. The present work was undertaken to study: (1) the effects of implanting pituitary glands, (2) the effects of injecting gonadotropic hormone substances in chickens and (3) the gonadotropic potency of the blood serum of certain classes of birds.

The poultry pituitary glands and the blood serum used in these investigations were obtained from the College Poultry Processing Laboratory and local commercial poultry processing plants. A few

mammalian hypophyses for special studies were obtained from the College Meats Laboratory. For the pituitary gland experiments 385 chickens were used, mostly Single Comb White Leghorns and New Hampshires. The work on blood serum involved 330 Single Comb White Leghorn male chicks which served as assay animals.

The results of this research revealed a significant increase in the growth of the testes and the pituitary gland of cockerels (four to ten weeks of age) due to implanting them with hypophyseal tissue. Body weight and comb development of these treated birds were unchanged by the treatment. Indications are that the fertility of low potency breeding males might be improved by implanting them with hypophyses obtained from cockerels twelve to sixteen weeks of age.

The experimental treatments of the laying pullets were varied to determine the following: (1) effects of the number of hypophyses implanted, (2) potency of glands obtained from different animal sources, (3) effects of implanting pullets at different times of the year, (4) effects of implantation at various points on the pullet's body, and (5) effects of subjecting glands to different treatments prior to implanting them. None of the pituitary

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b. Doctoral Thesis No. 1091. Submitted July 14, 1950.

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gland treatments altered the egg production, egg weight, fertility, or hatchability of the pullets. Treating broody hens with six cockerel hypophyses did not stop broodiness effectively, but injections of Synapoidin, a commercial gonadotropic hormone preparation, caused them to leave the nest. Hypophyseal implantation of pullets when they were one day of age decreased egg production. Fecundity was not affected by the treatment of pullets at twelve weeks of age and/or sexual maturity. Implanting pullets at one day and/or twelve weeks of age had no influence on their rate of body weight gain between one day old and sexual maturity.

Normal hypophyseal tissue was recovered from laying pullets twelve weeks after implanting them with six cockerel pituitaries. The glandular tissue

was absorbed by sixteen weeks after the operation. The treatment of laying pullets with pituitary gland implants caused no significant increase in the gonadotropic potency of their blood serum when measured by the chick testes growth method.

Testicular growth was stimulated in Single Comb White Leghorn chicks seven to sixteen days of age by injecting them with a powder which had been precipitated from the blood serum of chickens. The gonadotropic potency of the serum precipitate varied with the age and reproduction of the birds from which the samples were taken. Serum obtained from nonlaying hens exhibited more gonadotropic activity than that of layers and the potency of samples collected from young chickens was greater than that of serum obtained from fowls.

EFFECT OF VITAMIN C AND VITAMIN E DEFICIENCIES UPON NITROGEN CONSTITUENTS OF MUSCLE TISSUE¹

MARION BARCLAY²

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Experiments have been performed to show the influence of time in cold storage, heat under pressure, and autolysis on the nitrogen compounds of muscle. These were followed by a study of the effects of deficiencies of both vitamins C and E upon these compounds in guinea pig and rabbit muscle tissue.

When samples from five different beef muscles were excised and stored at 34°F. for periods ranging from one to thirty days, no changes were found in the total nitrogen of the homogenized tissue, in the total nonprotein nitrogen, in the amino acid nitrogen, nor in the ammonia nitrogen as determined by the methods described.

Pectoralis major muscles from chickens were analyzed after storage in the intact, but eviscerated, bird at 32°F. for zero to forty-eight hours. The total nitrogen data

are in excellent agreement from zero-hour to forty-eight-hour samples and the values show no change over the period of time studied. The nonprotein nitrogen fractions determined on tungstic acid filtrates increased with time of storage.

A comparison between the total nonprotein nitrogen in filtrates prepared with either tungstic acid or trichloroacetic acid showed that the trichloroacetic acid filtrates contained the greater quantity at all times, from zero-hour to forty-eight hours. There was a greater increase from the zero-hour to the forty-eight-hour period in the trichloroacetic acid filtrates than in the tungstic acid filtrates.

Commercially processed samples of muscle meats were analyzed for total nitrogen and for total nonprotein nitrogen in both types of filtrates. This study involved the effect of processing temperatures and showed the variation that can occur in the total nitrogen in such materials. It showed, also, that the total nonprotein values from the trichloroacetic acid filtrates were higher than the total nonprotein nitrogen values from tungstic acid filtrates.

1 a. Chairman of Committee, Oscar E. Tauber, Professor, Dept. of Zoology, Agricultural Experiment Station.

b. Doctoral Thesis No. 1162. Submitted May 9, 1951.

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A 5 per cent suspension of the pectoralis major muscles of the chicken was held under carefully controlled conditions of pH and temperature. At zero-hour, aliquots were removed for total nitrogen and for the preparation of both types of filtrates. The suspension was then incubated in order to study the enzymatic changes which would occur. Experiments showed that pH 4.00 and a temperature of 40° C. gave optimum activity as measured by an increase in the production of total nonprotein nitrogen.

Aliquots were removed after two, four, and six hours incubation. The total nonprotein nitrogen values obtained at zero-hour from the two filtrates were in close agreement. As the time of incubation increases, the values become increasingly divergent, with the total nonprotein nitrogen from the trichloroacetic acid filtrates increasing to the larger values. The probable significance of these two filtrates is discussed and may be summarized as follows: the tungstic acid filtrates are believed to contain only the low-molecular weight breakdown products of protein, the trichloroacetic acid filtrates contain, in addition, the intermediary products of protein breakdown. Hence, a greater increase in the total nonprotein nitrogen from the latter filtrate indicates a greater increase in the production of the intermediary products of protein breakdown under the conditions described.

Guinea pig experiments were conducted to determine the effects of a dietary vitamin C deficiency upon the nitrogen-containing compounds of muscle. A single experiment contained guinea pigs which had been brought to a state of very acute vitamin C deficiency by incorporating 0.378 g. of L-tyrosine into the diet daily. The values for total nitrogen in both the scorbutic and normal muscle were similar. The total nonprotein nitrogen from tungstic acid filtrates was greater in the normal samples.

The first group of a series was comprised of guinea pigs which had been brought to a state of typical acute scurvy by feeding ground, aerated Purina Rabbit Chow without added vitamin C. Although the values for total nitrogen were almost the same in both normal and scorbutic muscle, the values for total nonprotein nitrogen from tungstic acid filtrates were higher in the scorbutic samples.

In series 2 the total nitrogen in the scorbutic muscle was significantly higher than that obtained from the normal

muscle. The total nonprotein nitrogen from the tungstic acid filtrates expressed as per cent of total nitrogen was greater in the normal muscle samples. Histidine and tyrosine were found to be greater in the scorbutic sample; carnosine was greater in the normal muscle, and anserine was not found in significant quantities in either type of tissue.

In a more extensive and more reliable experiment, series 3, the muscle tissue from both the normal and scorbutic animals was employed to prepare nonprotein nitrogen filtrates by the two procedures mentioned above. The data indicate that in the scorbutic guinea pig muscle there are no protein intermediates produced, while in the normal samples these high molecular weight compounds were present. The total nitrogen values were consistently lower in the scorbutic samples.

Series 4 was composed of guinea pigs which developed a state of chronic scurvy, and upon which a comparison of the total nonprotein nitrogen from both types of filtrates was made. In these experiments the scorbutic muscle showed higher values in the trichloroacetic acid filtrates while in the tungstic acid filtrates the normal were higher. In these samples the total nitrogen values were approximately the same.

Vitamin E deficiency was produced in rabbits by means of a synthetic diet containing no vitamin E. A comparison was made between the normal and dystrophic muscle of the total nitrogen in the muscle and of the total nonprotein nitrogen found in the two types of filtrates. The total nitrogen was greater in the normal samples. The results show that, in dystrophic rabbit muscle, there is a greater quantity of protein intermediates formed than in the normal muscle, in which a larger quantity of the protein end products is found.

The common denominator linking vitamin C deficiency in the guinea pig and vitamin E deficiency in the rabbit in these experiments was the muscle degeneration. When total nitrogen values were compared, it was found, generally, that in both deficiencies the total nitrogen was lower in the affected muscle. In scorbutic guinea pig muscle no protein intermediates were found, while in the dystrophic rabbit muscle there is a greater quantity of these compounds present. In normal guinea pig muscle the protein intermediates were present, but in normal rabbit muscle there is a larger quantity of end products.

FECUNDITY AND TOTAL NITROGEN AND LIPID CONTENTS OF THE GREEN PEA APHID (*MACROSIPHUM PISI* [KALT.]) AS AFFECTED BY NUTRITIONAL CHANGES IN THE GARDEN PEA (*PISUM SATIVUM* L.)¹

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Two series of experiments were designed to determine the effect of nutritional changes in *Pisum sativum* upon the fecundity, and the nitrogen, lipid, and water compositions of *Macrosiphum pisi*. A supplementary series was also included to determine the changes in nitrogen and water compositions of *M. pisi* during growth and adulthood.

The first experiment consisted of progeny counts from aphids reared on *P. sativum* grown in full nutrient, and in nitrogen, phosphorus, potassium, calcium, or magnesium deficient solutions. To test different degrees of severity of the deficiencies, one series of plants was infested at three weeks of age and a second series at four weeks of age. Nutrient deficiencies in *P. sativum* significantly reduced the fecundity of *M. pisi*, with a greater reduction occurring at four weeks than at three. Nitrogen or phosphorus deficiency caused a greater reduction in fecundity than did that of potassium, calcium, or magnesium. Aphid infestation severely injured the weaker nutrient-deficient plants, and decreased their life span. These detrimental changes, in turn, reduced the longevity of *M. pisi*. As a result, the period of reproduction was shortened, and number of progeny smaller.

In terms of field conditions, it is likely that *P. sativum* grown on soils severely deficient in either nitrogen, phosphorus, potassium, calcium, or magnesium would be injured worse by *M. pisi* than would plants grown on soils of good fertility, not because of any greater number of aphids, but because whatever aphids were present would do greater damage to the less vigorous plants.

The second series of experiments was designed primarily to determine the effect of changes in carbohydrate and nitrogen contents of *P. sativum* upon the fecundity of *M. pisi*. The different carbohydrate and nitrogen levels were obtained by modifications of sources of available light and nitrogen. The high carbohydrate level was obtained by growing plants under full sunlight and low moisture; low carbohydrate level by growth under reduced light and increased moisture. To obtain different nitrogen levels light and moisture combinations, ammonium nitrate was applied at the rate of 0, 50, and 200 pounds of actual nitrogen per acre.

The progeny of aphids nourished by these plants was analyzed for nitrogen, lipid, and water contents. As a supplement to this investigation, the average wet and dry weights, and average nitrogen and water contents of early fourth instar females were determined. In addition, progeny counts were made on both four- and six-week plants under high light and low moisture to obtain additional data on the effect of different ages of the plants on reproductive ability of the aphid.

The data showed that, as the level of nitrogen fertilization within the high light and low moisture combination increased, the total and soluble nitrogen and insoluble protein nitrogen, as a per cent of green weight of *P. sativum*, also increased, except for the insoluble protein nitrogen which remained unchanged in the four-week plants. Also, in both the four- and six-week plants under high light and low moisture, total sugars as a per cent of green weight decreased as the level of nitrogen fertilization increased. The fecundity of *M. pisi* reared on these plants decreased as the level of nitrogen fertilization increased. Also, lipid, as a per cent of dry weight, as well as the average individual content of the insect, likewise decreased. However, nitrogen, as a per cent of dry weight and average individual content, increased as the level of nitrogen fertilization increased. The average indi-

1 a. Chairman of Committee, Oscar E. Tauber, Professor, Dept. of Zoology, Agricultural Experiment Station.

b. Doctoral Thesis No. 1114. Submitted October 7, 1950.

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vidual weight of the aphid progeny also increased. The difference in per cent sugars among nitrogen levels is interpreted as being largely responsible for the increase in per cent lipid of the aphid and this, in turn, responsible for the difference in fecundity.

Within the high light and low moisture level, *P. sativum*, at four weeks of age, was higher in total and soluble nitrogen as a per cent of green weight, and lower in total sugars, likewise expressed, than plants at six weeks of age. At six weeks, the plants on the higher levels of nitrogen were richer in soluble protein nitrogen as a per cent of green weight than those at four weeks of age, whereas the plants on the lowest level of nitrogen showed the reverse effect.

Along with the above changes in the host plants, aphids reared on the six-week plants were higher in content of lipid, expressed both as a per cent of dry weight and as average individual content, than were aphids reared on the four-week plants. Likewise, the average individual weight, and average individual content of nitrogen of the aphid were greater when reared on the six-week plants. However, nitrogen as a per cent of dry weight was less in aphids reared on the six-week plants as compared to rearings on the four-week plants, while the fecundity of the females was the same regardless of the age of the plant.

The experimental design did not permit a statistical evaluation of the significance of the difference between light and moisture levels. However, the differences were of sufficient magnitude to be of physiological importance.

P. sativum reared under low light and high moisture, at five weeks of age were lower in total nitrogen, insoluble protein nitrogen, and total sugars as a per cent of green weight than those at four weeks of age under high light and low moisture. However, in a similar comparison, there was no difference in per cent soluble nitrogen. When compared as a group to the six-week plants, under high light and low moisture, the plants on low light and high moisture were no different in total nitrogen as a per cent of green weight. However, the plants on the lowest level of nitrogen, under high light and low moisture at six weeks, were lower in per cent total nitrogen while those on the higher levels of nitrogen were actually higher in content of this component than were similar plants under low light and high moisture. In contrast, the low light and

high moisture plants, at five weeks, were higher in per cent soluble nitrogen and lower in per cent insoluble protein nitrogen and total sugars than were the high light and low moisture plants at six weeks.

Between levels of light and moisture combinations, *M. pisi* showed a reduction in fecundity when reared on the low light and high moisture plants. Lipid as a per cent of dry weight, average individual content of nitrogen, and average individual weight likewise decreased when reared on plants grown under low light and high moisture. Associated with a decrease in lipid content, the nitrogen, as a per cent of dry weight, was higher in aphids reared on the low light and high moisture plants.

The difference in fecundity is concluded as being due to the reduced lipid content of the aphids reared on the low light and high moisture plants and this, in turn, as being due to the reduced sugar content of these plants.

Among nitrogen applications, within the low light and high moisture level, even though total and soluble nitrogen as a per cent of green weight of *P. sativum* increased with the increase in nitrogen fertilization, *M. pisi* showed no significant change. Also, there was no change in per cent insoluble protein nitrogen or total sugars of *P. sativum* among nitrogen levels.

The injury to *P. sativum* by *M. pisi* was worse on the lower levels of nitrogen application within the high light and low moisture combination. Between light and moisture levels, the worst injury was to the plants on low light and high moisture. The conclusion was, therefore, that injury to *P. sativum* was dependent, not only upon the amount of nitrogen in the plant, but also upon the degree of differentiation. Consequently, soil and climate conditions favoring an ample supply of nitrogen, and at the same time affording a good degree of differentiation, were concluded as being conducive to a type of plant growth more tolerant to injury by *M. pisi*.

The studies on changes in nitrogen and water composition of *M. pisi* during growth and early adulthood showed a significant decrease in nitrogen as a per cent of dry weight during the first two instars, followed by a gradual increase during the last two instars and early adulthood. The degree of hydration followed a similar trend.

Although there were no data on changes in lipid during similar stages, these changes in nitrogen and water contents were concluded as being correlated with a storage

of lipid during the last stages of growth and early adulthood, the per cent of nitrogen and water increased.

Because of the close coincidence of time

of depletion of lipid stores and the time of formation of young, it was concluded that lipid played some active role in reproduction.

CONTINUOUS SAMPLING OF INTERMITTENT RUNOFF FROM AGRICULTURAL WATERSHEDS¹

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The United States Department of Agriculture working through its Soil Conservation Service is carrying out a watershed treatment program in the Little Sioux watershed of western Iowa. The program includes mechanical and agronomic measures to control erosion, reduce downstream flood and sediment damages, and increase the agricultural income of the area. Much of the justification for this program rests upon reduction of sediment loads carried into the flood plains of major streams. Little factual information is available relative to the effectiveness of this program in reducing such sediment loads.

The Iowa Agricultural Experiment Station is cooperating with the Soil Conservation Service in a research program designed to measure the effectiveness of watershed treatments in the Little Sioux Basin. As this research program developed, a technique of runoff sampling particularly adapted to flows from areas of the order of 1,000 acres was needed. No such technique was available.

An apparatus for sampling runoff from these areas was developed. As originally conceived, this apparatus was to consist of a narrow (less than one-half inch) slot in the top of a conduit extending downstream from the crest of a notch spillway. The conduit was to be depressed by some angle of the order of 10° to 20° from the horizontal. A portion of the flow through the structure was to enter the narrow slot and flow through the conduit to a suitable container. The basic require-

ments for this device were set forth as follows:

1. The slot should take in a constant proportion of the flow through the notch spillway.
2. This proportion should not in any twenty-four hour runoff period accumulate to a volume greater than could be reasonably stored in a container at the structure.
3. The apparatus should automatically clean itself of debris carried over it by the runoff.

Laboratory studies were conducted to define the performance of the sampler. These studies were designed in recognition of the fundamental variables influencing the hydraulic behavior of such a device. Application of the methods of dimensional analysis to the problem led to the conclusion that the performance of a slotted conduit intersecting the nappe of the flow through a drop spillway would be defined by the function:

$$S = f(\alpha, \beta, b_n/b_s, d_c/b_s, d_c/d, R),$$

where:

$$S = Q/q$$

Q = the total discharge through the notch spillway

q = the discharge from the slotted conduit

α = angle between the sides bounding the sampling slot

β = angle of declination of the slotted conduit

b_n = width of the notch of the structure

b_s = width of the slot in the conduit

d_c = critical depth of flow through the notch

d = actual depth of flow at the crest of the notch

R = Reynolds number of flow into the slot

The nature of the function S was de-

- 1 a. Chairman of Committee, G. M. Browning, Professor, Dept. of Agronomy, Ass't Director, Agricultural Experiment Station and Agricultural and Home Ec. Extension Service.
- b. Doctoral Thesis No. 1171. Submitted June 7, 1951.
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terminated experimentally. Models of samplers having values of α of 20, 60, 100, and 140 degrees were constructed. These models had values of b_s adjustable from zero to 0.04 foot. The angle β was adjustable from zero to 20 degrees. Tests were conducted at the discharge end of a rectangular flume 1 foot wide. The flow rate through the flume was adjustable to give a value of d_c up to 0.67 foot. The Reynolds number was varied by controlling the temperature of the water from 40 to 90 degrees Fahrenheit. Tests were conducted through the following ranges of the dimensionless parameters involved:

$$\alpha = 20^\circ \text{ to } 140^\circ$$

$$\beta = 5^\circ \text{ to } 20^\circ$$

$$b_n/b_s = 47 \text{ to } 255$$

$$d_c/b_s = 10 \text{ to } 180$$

$$d_c/d = 1.5 \text{ only}$$

$$R = 1,600 \text{ to } 3,600$$

From these tests the following empirical relationships were developed for the hydraulic behavior of the slotted conduit:

$$\text{at } \alpha = 20^\circ$$

$$d_c/d = 1.50$$

$$S = 8.7 + 0.630b_n/b_s + 0.27d_c/b_s \quad (1)$$

$$\text{at } \alpha = 60^\circ$$

$$d_c/d = 1.50$$

$$S = 11.8 + 0.367b_n/b_s + 0.46d_c/b_s \quad (2)$$

$$\text{at } \alpha = 100^\circ$$

$$d_c/d = 1.50$$

$$S = 1.5 + 0.342b_n/b_s + 0.56d_c/b_s \quad (3)$$

$$\text{at } \alpha = 140^\circ$$

$$d_c/d = 1.50$$

$$S = -10.7 + 0.320b_n/b_s + 0.58d_c/b_s \quad (4)$$

The variables β and R were found to have no influence on S in the range tested. The above relationships showed that a

conduit with a slot of uniform width would not meet the requirement of taking a constant portion of the flow through the notch spillway structure.

Equation three was modified and solved simultaneously with an equation derived for the intersection of the centerline of the nappe with a slot at an angle of 10° and originating 0.08 foot below the crest to give

$$b_s = (0.420x + 0.436)/(S - 0.33) \quad (5)$$

where x = horizontal distance measured downstream from the crest.

A model with α equal to 60 degrees was adjusted to a variable b_s in accordance with equation 5 at an S of 100. Tests of this model were conducted at eleven flow rates ranging from 0.5 to 3 c.f.s. through the 1-foot flume. Measured values of S from these tests range from 97 to 105 in a random manner.

This model was used as the basis for the design of a field installation for the notch spillway at station 23+00 of the main gully of the Theobald sub-water-shed, Woodbury County, Iowa. The drainage area above this station includes 762 acres. Peak runoff rates from this area are controlled by three detention reservoirs. The notch spillway is a reinforced concrete notch 30 feet wide and 4.5 feet deep. The fall through the structure is 7 feet and the apron protection is of the Morris and Johnson type.

The equipment consists of a slotted conduit designed in accordance with equation 5 with $\alpha = 60^\circ$, $\beta = 10^\circ$; a sampling wheel of the Pomerene type which takes 1/100 of the discharge from the conduit; and a 27 cubic foot tank for storage of the sample. At this writing the sampler assembly has been constructed and will soon be installed in the field.

CHEMICAL EVIDENCE OF THE QUANTITATIVE THIAMINE AND RIBOFLAVIN REQUIREMENTS OF THE RAT DURING PREGNANCY AND THE DEVELOPMENT OF THE FETUS¹

MARGARET LOUISE BARRETT²

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A highly standardized group of stock rats has been sacrificed at thirteen intervals during the gestation period to permit a continuous study of the prenatal growth of the fetus and a measurement of the deposition of thiamine and riboflavin in fetal and placental tissues.

The concentrations of thiamine and riboflavin in maternal liver and carcass have been determined at intervals during the gestation period in order to detect possible variations in the vitamin stores of the female as pregnancy progressed.

Metabolism studies have been conducted on a group of pregnant stock rats and their nonpregnant litter mates as a second means of estimating quantitative needs for the two vitamins throughout pregnancy.

A detailed account of the embryology of the rat is presented, and highly magnified photographs of the developing rat fetuses, produced by stock animals of the Foods and Nutrition colony, are included.

Very rapid prenatal growth of the rat occurred between the eighteenth day of pregnancy and parturition. During this five-day interval the weight of the fetal tissue increased four-fold. Total thiamine present in this tissue increased from 26 to 126 micrograms, while the quantity of riboflavin deposited in the fetal tissue rose from 12 to 136 micrograms. Placental tissue at term was found to contain only minor amounts of either riboflavin or thiamine; such tissue contributed very little to the increasing needs for the vitamins during reproduction. An interesting increase in hepatic stores of thiamine was observed in the pregnant stock animals. The maximum thiamine content of the

liver was attained within one or two days of parturition. There appeared to be no significant change in the maternal hepatic stores of riboflavin during the period of gestation, and concentrations of thiamine and riboflavin of the carcasses of the females were essentially unaltered throughout pregnancy.

Vitamin demands to provide for the incorporation of thiamine and riboflavin into rapidly growing fetal and placental tissue reached a maximum on the twenty-first day of pregnancy. At this stage of the reproductive cycle, tissue changes indicated that 76 micrograms of extra thiamine and 56 micrograms of additional riboflavin were needed above the customary requirements of the nonpregnant adult female.

The excretions of thiamine and riboflavin by the kidneys which were interpreted to reflect surplus dietary intakes of the two vitamins revealed an increased requirement for both vitamins during the last quarter of the gestation period.

Metabolism studies and analyses of the developing fetal and placental tissues plus changes in the maternal reserves of thiamine in the liver suggest that it is desirable to include 100 micrograms of riboflavin and 125 micrograms of thiamine per day in the ration of pregnant rats during the last one third of the gestation period. These amounts supply a large surplus of both vitamins during earlier phases of the pregnancy period.

Data encountered during these studies revealed considerable differences in the total body stores of riboflavin and thiamine between young adult stock females and animals which had produced one or two litters of young. These differences show that the young adult rat is still growing and adding to its body stores of vitamins beyond the time customarily recognized as the growth period. Dietary needs for thiamine and riboflavin during reproduction are therefore greater for the younger animals.

1 a. Chairman of Committee, Gladys Everson, Professor, Dept. of Foods and Nutrition, Agricultural Experiment Station.

b. Doctoral Thesis No. 1083. Submitted July 13, 1950.

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HERITAGE AND NONHERITABLE RELATIONSHIPS OF AGRONOMIC CHARACTERS IN SUCCESSIVE GENERATIONS OF SOYBEAN CROSSES¹

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Selection is effective in populations which are genetically variable. The degree of correspondence between genotype and phenotype is important in determining the permanent response of a population to selection.

Segregation for maturity date, plant height, seed yield, and lodging were studied in three successive generations in three soybean crosses, namely, Hawkeye x Ottawa Mandarin, Lincoln x Ottawa Mandarin, and Lincoln x Hawkeye. Heritability of and the interrelationships among the attributes were determined. The three parental varieties ranked from least to most for the four attributes of yield, maturity, height, and lodging were as follows: Ottawa Mandarin, Hawkeye, and Lincoln.

Spaced F_1 plants of the three crosses were intermediate in maturity and height to their parents. Heterosis for seed yield was observed, particularly in the Lincoln x Hawkeye cross.

Transgressive segregation occurred in both directions for yield and height in all F_2 populations and for maturity in Lincoln x Hawkeye. The largest total F_2 variance for all characters was obtained in the Lincoln x Hawkeye cross and the lowest total F_2 variance was found in Hawkeye x Ottawa Mandarin.

In each cross, differences were large for all characters between F_3 progenies from 188 randomly selected F_2 largest total variance of all crosses. F_4 progenies were grown from two plants selected in each F_3 family. The components of variance for among F_3 family means were larger than the components of variance between F_4

progenies within F_3 families for each character and every cross.

Heritabilities were estimated by regressions of progeny means on parental values. Average heritabilities for all crosses among F_2 plants were: maturity, 75 per cent; height, 60 per cent; and yield, 18 per cent. Heritability estimates for maturity and height in F_2 plant populations were generally larger, and those for yield were lower, than the F_3 estimates. Heritability for all characters in F_3 progenies was estimated from regressions of F_4 progeny means on F_3 progenies. These regressions were larger than the regressions for F_4 progeny on F_3 plants but the crosses maintained the same ranks. Heritability estimates for degree of lodging in F_3 progenies were: Hawkeye x Ottawa Mandarin, 17 per cent; Lincoln x Ottawa Mandarin, 38 per cent; and Lincoln x Hawkeye, 75 per cent.

Phenotypic correlations between maturity date, height, and yield among F_2 and F_3 plants, and F_3 and F_4 progenies, were positive and large. These characters were positively associated with lodging in the F_3 and F_4 progenies.

Genetic correlations between maturity date, height, and yield in F_2 and F_3 plants and F_3 progeny were calculated from progeny-parent regressions. The traits were related to a considerable degree and it appeared that they were determined by a complex of genes. Genetic correlations were similar in direction and larger in magnitude than the corresponding phenotypic correlations.

On the basis of these results, it was suggested that effective plant selection could be made for maturity and height as early as the F_2 . Selection for yielding ability and lodging resistance in spaced plants was considered ineffective. Selection of yield should be more on a progeny row basis in the F_4 or later generations when differences among lines may be measured more accurately.

- 1 a. Chairman of Committee, I. J. Johnson, Professor, Dept. of Agronomy, Agricultural Experiment Station.
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A COMPARISON OF METHODS OF MEASURING THE THICKNESSES OF THIN METAL FILMS¹

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One of the most popular methods of making a direct determination of the thicknesses of thin metal films has been to weigh the amount of metal deposited on a given area and calculate the thickness by assuming a constant density for the deposited material. Although there are reasons to believe that the density of the metal deposited as a thin film is different from that of the bulk metal, no accurate measurements have been made. Obviously the assumption of constant density, if such is not the case, will give inaccurate thickness determinations.

A second method of determining the thicknesses of thin metal films, which makes use of multiple-beam interference, was introduced by Tolansky in 1945. Since that time it has become very popular mainly because it does not require that the density be known. However, it must be assumed that when the opaque, reflecting layer of silver is deposited over the step formed by the edge of the film to be measured, the silver builds up equally on the substrate and on the metal film. There is evidence to indicate that this is not the case and therefore there is introduced an error in the thickness measurements.

Since each of the two methods mentioned introduces an uncertainty in the thickness measurements, a third method was employed which was free of the difficulties encountered in the other two. This method made use of the shadow-casting technique of electron microscopy. A scarp of the metal film was produced by scratching the film. The scarp was thin shadowed at a known angle of incidence with gold evaporated from a hot filament in a vacuum. The length of the

shadows was determined by use of the electron microscope and the thickness calculated from the angle of incidence and the shadow length. The accuracy of measurement by this method was comparable to that of the other two. Therefore, the results obtained from a direct comparison of thicknesses determined by each of the other methods with those determined by the shadow-casting method should indicate whether or not these methods are measuring the same physical quantity.

A direct comparison of the three methods was carried out as follows. Equivalent film samples less than 1,000 A. U. thick were prepared by evaporation of gold from a hot filament in a kinetic vacuum at a pressure less than 10^{-4} millimeter of mercury and allowed to condense on glass microscope slides. Thickness measurements were made by the shadow-casting method on one half of the sample and interferometric measurements made on the other half. A second set of samples was prepared in the same manner but gold enriched with radioactive Au¹⁹⁸ was deposited. The weight of the metal deposited on each slide was determined by comparing the counting rate for each sample with that of a standard sample which had been accurately weighed. This eliminated the weighing of very thin samples. After a radioactive count was taken the same sample was then measured in the interferometer. The results obtained from each of the comparisons were plotted in such a manner as to give a direct comparison of all three methods.

Such a comparison indicates that the interferometric method measures a thickness about 16 to 20 per cent less than the shadow-casting method. This is probably due to a "packing in" of the reflecting silver layer on the gold film being measured. The results further indicate that the density of the metal when deposited as a very thin film is not constant, but that it is less than that of the bulk metal and decreases with thinner films.

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ACTION OF CERTAIN VIRUCIDAL AGENTS ON LACTIC STREPTOCOCCUS BACTERIOPHAGE¹

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The persistence of active lactic streptococcus bacteriophage in air contaminated with atomized infected whey was measured, the possibility of inactivating airborne lactic streptococcus bacteriophage by means of aerosols of certain virucidal agents was investigated, and the action of certain virucidal agents on lactic streptococcus bacteriophage in dilutions of whey was determined. F10, F67 and F69 bacteriophages active against *Streptococcus cremoris* strains 122-1, 144F and ML1 respectively, and the virucidal agents ethylene glycol, propylene glycol, triethylene glycol, calcium hypochlorite, chloramine-T, alkyldimethylbenzylammonium chloride, N-(acylcolaminoformylmethyl)-pyridinium chloride, 9-octadecenyldimethylethylammonium bromide, methyl-dodecylbenzyltrimethylammonium chloride and diisobutyl-(or p-tertiaryoctyl)-phenoxyethoxyethyl-dimethylbenzylammonium chloride were selected for the investigation.

The phages were prepared in milk, the acid whey from which was filtered through a #03 Sela microporous filter. Filtrates containing the respective phages were mixed for simultaneous testing and the pH was adjusted when necessary by the addition of IN NaOH. The titers of the filtrates and phage-carrying mixtures were determined by a three-tube limiting dilution technique, using litmus milk fortified with nonfat dry milk solids and V-8 vegetable juice as the medium.

The glycol solutions were prepared volumetrically. The strengths of the hypochlorite and chloramine-T solutions were determined by titration with 0.1 N sodium thiosulphate, using a starch indicator and regarding 1 milliliter (ml.) of the thiosulphate solution to be equivalent to 0.003546 gram (g.) of available chlorine. Solutions of diisobutylphenoxyethoxyethyl-dimethylbenzylammonium chloride were prepared

gravimetrically. Solutions of the other quaternary ammonium compounds were prepared volumetrically from industrial solutions according to the manufacturers' statements of concentrations.

DeVilbiss atomizers No. 127 were used for atomizing whey filtrates for the infection of a closed room having a volume of 1,370 feet.³ Phage was recovered by aspiration of 6.7 ft.³ of air through distilled or buffered distilled water and by settling on stainless steel discs or petri dishes.

Aerosols of the glycols, calcium hypochlorite, chloramine-T and alkyldimethylbenzylammonium chloride were dispersed into the infected room by means of DeVilbiss No. 127 atomizers. Tubes and dishes for the collection of samples after the treatment of the room with calcium hypochlorite or chloramine-T were charged with distilled water containing 3.2 milligrams (mg.) of sodium thiosulphate per liter and 1/3,200 M phosphate buffer adjusted to pH 7.2.

The actions of the virucides on bacteriophages in 1:2, 10⁻¹ and 10⁻² dilutions of whey at 25°C. were tested for exposures of 15, 30, 60, 120 and 300 seconds. At least 14-fold the theoretical amounts of sodium thiosulphate were used to inhibit the action of available chlorine at the ends of the exposure periods. One-hundred-fold and 700-fold amounts of asolectin and Tween 80, respectively, as minima were used to inhibit the action of the quaternary ammonium compounds.

Most of the *Streptococcus cremoris* phage carried in whey filtrates atomized into the air settled or otherwise disappeared in 1 to 2 hours but some phage was recovered in certain trials 7 to 8 hr. after dispersal. It was possible in some cases to resuspend the phage in the air after settling. Phage was recovered on surfaces in the room 2 days after dispersal into the air.

Glycols were not found sufficiently effective to recommend their use either as aerosols or liquids in control of lactic streptococcus phage. Aerosols of calcium hypochlorite supplying a minimum of 0.61 g. of available chlorine per 1,000

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ft.³ of air completely inactivated air-borne phage under the conditions of this investigation. Alkyldimethylbenzylammonium chloride aerosol had a highly astringent effect upon the respiratory tract of persons in the room where it was dispersed. A concentration of the compound which still failed to inactivate the phage was intolerable.

When the tests were carried out on bacteriophage suspended in a 1:2 dilution of whey with an original pH of 5.0, 400 parts per million (ppm.) of available chlorine from calcium hypochlorite inactivated the three phages used in this investigation in 15 sec. More than 500 ppm. were found necessary to inactivate the phages in 300 sec. in 1:2 whey dilutions at pH 6.4-6.6. The phages suspended in a 10^{-1} dilution of whey with an original pH of 5.0 were inactivated in 60 sec. by 100 ppm. of available chlorine from calcium hypochlorite but survived in small numbers an exposure of 300 sec. at pH 6.9-6.95. The phages suspended in 10^{-2} dilutions of whey at pH 5.4-6.0 were inactivated in 15 sec. by 25 ppm. of available chlorine from calcium hypochlorite but were not inactivated in 300 sec. by the same concentration of chlorine at pH 7.2-7.4.

There was some evidence of differences in susceptibility to available chlorine between the three phages but the data were not consistent on this point. Available chlorine from chloramine-T was much slower in action and was very noticeably less effective even after 300 sec. exposures than available chlorine from calcium hypochlorite. A higher pH level in the former may have been a factor.

A concentration of 1,000 ppm. of alkyldimethylbenzylammonium chloride inactivated the phages in 30 sec. when they were suspended in 1:2 dilutions of whey at pH 6.6-6.65 but failed to inactivate them at pH 4.6. Six hundred ppm. of the compound inactivated the phages in 120 sec. in a 10^{-1} dilution of whey at pH 4.8 and 300 ppm. inactivated the phages in 15 sec. at pH 6.9. When the phages were suspended in 10^{-2} dilutions of whey, 50 ppm. of the quaternary compound inactivated the phages in 15 sec. at pH 5.1 but 25 ppm. was insufficient to inactivate them at pH 7.0-7.05.

Presence of organic matter decreased the effectiveness of either available chlorine or the quaternary ammonium compounds studied in the destruction of the phage. Available chlorine was more effective in the destruction of the phages at the lower pH levels than at the higher levels within the range of pH 4.6 to 7.4. The opposite was true of alkyldimethylbenzylammonium chloride.

No outstanding differences in the actions of the five quaternary ammonium compounds on lactic streptococcus bacteriophages were observed.

The use of 1 g. of available chlorine per 1,000 ft.³ from hypochlorite in a fine aerosol is recommended for the inactivation of air-borne lactic streptococcus bacteriophage. A final rinse containing 100 ppm. of available chlorine from hypochlorite or 200 ppm. of an approved quaternary ammonium compound equal in effectiveness to alkyldimethylbenzylammonium chloride is suggested for the destruction of the phage on cleaned surfaces.

STERIC HINDRANCE IN ARYLSILICON COMPOUNDS¹

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Several investigators have postulated that steric hindrance is responsible for some unusual reactions of various organosilanes. A number of new 1-naphthylsilicon compounds were synthe-

sized to extend this study. Tri-1-naphthylchlorosilane is considerably more resistant to hydrolysis than the corresponding non-sterically-hindered triarylsilanes. Likewise, tri-1-naphthylsilane did not evolve hydrogen when treated with potassium hydroxide in piperidine while triphenylsilane gave an immediate rapid stream of gas when subjected to this treatment. Hexa-1-naphthylidisilane, hexa-1-naphthylidisiloxane, and tetra-1-naphthylsilane could not be made by methods that afford fair yields of the corresponding

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phenyl derivatives. A bimolecular nucleophilic substitution reaction mechanism (SN₂) is employed to account for this behavior and to postulate that steric factors are operating in these reactions.

During the course of this investigation the following new compounds were synthesized: 1-naphthyltriphenylsilane, m. p. 172-172.5°; di-1-naphthyl-diethoxysilane, m. p. 100-101°; di-1-naphthyl-diphenylsilane, m. p. 194-195°; tri-1-naphthyl-ethoxysilane, m. p. 186-186.5°; tri-1-naphthyl-chlorosilane, m. p. 210-211°; tri-1-naphthyl-bromosilane, m. p. 212-213°; tri-1-naphthylsilane, m. p. 235-236°; tri-ethoxysilane, m. p. 186-186.5°; tri-1-naphthylphenylsilane, m. p. 192-193°; and tri-1-naphthyl-*p*-tolylsilane, m. p. 232-233°.

These syntheses illustrate the value of the halogen-metal interconversion method of preparing organolithium reagents.³ The use of 1-naphthyllithium prepared by the direct procedure⁴ gave substantially negative results due to the presence of impurities that were difficult to remove, while a clean product was obtained easily by employing the halogen-metal interconversion procedure.

On the other hand, although tetra-2-naphthylsilane was easily prepared by reacting silicon tetrachloride and 2-naphthyllithium prepared by both the direct and the halogen-metal interconversion method, the tri-2-naphthylsilicon compounds were not obtained by using 2-naphthyllithium made by either method. It is believed that this failure is partly attributable to the absence of a suitable method for determining the exact yield of 2-naphthyllithium. Other factors, such as the rate of adding the organolithium reagents and efficiency of stirring, are undoubtedly involved since tetra-2-naphthylsilane was obtained in 20-30 per cent yield from the reaction of only two equivalents of 2-naphthyllithium with one of silicon tetrachloride.

The presence of lithium addition products in the preparation made by the direct procedure leads to high titration values. Carbonation of aliquots and isolation of the acid is probably the most satisfactory method of determining the extent of halogen-metal interconversion and several indeterminate factors in this procedure apparently lead to low values.

An examination of the Stewart model of tri-1-naphthylphenylsilane revealed that the ortho substituents may be large enough to cause restricted rotation. This steric hindrance may eventually provide

additional evidence for a new type of "windmill" or "propellor" isomerism proposed by Lewis and Calvin.⁵ Theoretically, restricted rotation of the groups in tri-1-naphthylphenylsilane gives rise to a maximum of four pairs of enantiomorphs or eight diastereoisomers. Experiments designed to test this hypothesis were unsuccessful in that the desired compounds could not be synthesized.

A method was developed to create a reactive group in tetraphenylsilane by the action of *N*-bromosuccinimide on triphenyl-*p*-tolylsilane. Several new compounds were prepared: *p*-triphenylsilylbenzyl bromide, m. p. 175-176°; -benzal bromide, m. p. 184-184.5°; -benzyl alcohol, m. p. 54-55°; -benzaldehyde, m. p. 110-111°; and -benzoic acid, m. p. 213-214°. The oxime, m. p. 194-195°, and thiosemicarbazone, m. p. 234-235°, of *p*-triphenylsilylbenzaldehyde were made for additional structure proof. *p*-Triphenylsilylbenzoic acid was also made by the direct oxidation of triphenyl-*p*-tolylsilane with chromic oxide.

The above compounds were made chiefly to perfect a procedure for preparing tri-1-naphthylphenylsilane containing a functional group for the purpose of resolving possible optical isomers. Unfortunately, although *N*-bromosuccinimide apparently reacted with tri-1-naphthyl-*p*-tolylsilane, no sharp-melting products could be isolated from the reaction mixture.

A unique cyclodehydrogenation reaction was observed to occur incidental to the preparation of 1-naphthyllithium. It is believed that this reaction is effected by the action of lithium metal on certain intermediate biaryl compounds. The action of lithium metal on 1,1'-binaphthyl gave a 50-55 per cent yield of perylene. Experiments were carried out to elucidate the mechanism of this reaction but no definite conclusions were obtained. It was found that 1,1'-binaphthyl, 2,2'-binaphthyl, and 9,9'-biphenanthryl apparently add four atoms of lithium per mole of biaryl. However, except for perylene in the specific case mentioned, the end-products of these reactions could not be characterized. Attempts to identify the organic acids formed by carbonating these lithium-addition complexes were also unsuccessful.

3 H. Gilman and F. W. Moore, *J. Am. Chem. Soc.*, **62**, 1843 (1940).

4 H. Gilman, E. A. Zoelner, and W. M. Selby, *J. Am. Chem. Soc.*, **54**, 1957 (1932).

5 G. N. Lewis and M. Calvin, *Chem. Revs.*, **25**, 273 (1939).

The reaction of 1-naphthyllithium and an alkyl halide occurs principally as a side reaction during the use of the halogen-metal interconversion method. However, it was shown that this method gives excellent yields of alkylnaphthalenes that are not readily accessible by other methods.

Benzyl chloride was shown to react abnormally with 1-naphthyllithium. A product that was not the expected 1-benzyl-naphthalene was obtained in about 60 per cent yield. Several unsuccessful

experiments were carried out in an attempt to prove that this material is the unreported 1-naphthylphenylbenzylmethane.

Tri-*p*-tolylphenylsilane and di-*p*-tolyl-diphenylsilane were found to melt at 180-181° and 121-122°, respectively, while the reported values are 127-128° and 176-177°. These compounds were prepared in our investigation by the separate treatment of phenyltrichlorosilane and diphenyldichlorosilane with *p*-tolyllithium.

ECONOMICS OF MARKETING HOGS BY CARCASS WEIGHT AND GRADE¹

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The objectives of this study were: (1) to outline the characteristics of the present system of marketing hogs in the United States; (2) to outline the ways in which the present system of marketing hogs deviates from the "Ideal Marketing System";³ (3) to investigate the alternative method of marketing hogs by carcass weight and grade and to show by theoretical models whether this system can satisfy the conditions necessary for an "Ideal Marketing System"; (4) to outline hypotheses that need empirical verification; and (5) to test some of the hypotheses outlined by the theoretical models.

Hogs are usually sold in the United States on a live basis. There is little or no sorting or pricing on the basis of quality. The prices paid to producers vary only with the variation in the weight of the live hog.

Experimental evidence indicates that under the present live buying system, hog

buyers cannot estimate accurately carcass grade and dressing percentage. Therefore, hogs of a given weight are sold near the average price.

The pricing mechanism in the market does not pass on to the producer the consumer's desires for quality. This prevents optimum adjustment of production to consumer's demand for quality or optimum combinations of fat and lean cuts.

As a result of an inefficient pricing mechanism, productive resources at the farm level are wasted. All animals are discounted the average amount of loss due to fill and physical defects. The individual producer is competitively forced to fill his hog constituting a loss of productive resources. There is no incentive to reduce the losses from fill, bruising and disease because livestock buyers are unable to accurately determine the extent of fill, bruising, and disease losses from observation of the live animal.

Market news cannot be accurately relayed to the producer because of inaccuracy in live grading methods and live grade standards. Therefore, marketing resources are not used most efficiently and too many resources may be used in moving the hog to market. Because the producer does not know accurately the quality of meat he is producing, he does not know his exact competitive bargaining position.

If it is assumed that a perfectly functioning system of marketing hog by carcass weight and grade is in effect and accurate and acceptable carcass grade standards have been established then, theoretically,

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3 An "Ideal Marketing System" is one that will accomplish the following: (1) determine consumer's demand for products, (2) determine the consumer's demand for marketing services, (3) provide an effective price mechanism that will reflect to the producer consumers' desires for goods and services, and (4) reduce marketing costs to a minimum.

the marketing of hogs by carcass weight and grade would make it possible for the buyers and sellers to determine the true value of the hog carcass. Therefore, the pricing mechanism in the market could express the consumer's desires for quality and quantity to the producer.

Producers would, in the long run produce more high quality pork and less low quality pork. The distribution of the income from the production of pork would be changed. Producers of high quality pork would receive increased returns per unit of production and producers of low quality pork would receive less for each unit of production. In the long run it would be possible to equate the marginal rate of transformation between pork and any other product with the marginal rate of substitution between pork and any other product for the community which is consuming them.

There would be no incentive to fill hogs before sale and losses due to disease and bruising could be allocated to those responsible for the losses. There would be incentive to eliminate fill and reduce losses due to bruising and disease, thus reducing the cost of pork production.

The producer would have increased bargaining power. He could be provided with a more accurate language for price quotations and would not have to consider relative excretory shrinkage between alternative markets. The grade prices would be agreed upon while the hogs were still on the farm.

Increased knowledge as to the best outlet for the produce hogs would reduce marketing costs. Duplication of market functions would be eliminated; buying costs would be reduced; transportation costs would be minimized and the buying of hogs by description could be initiated.

The reduction in certain marketing and production costs would be felt in the short run by both the producer and the consumer. But in the long run the consumer will stand to gain most.

To substantiate the hypotheses that an ideal carcass system could be established in the United States, several technical and economic problems would require further investigation. Some of the problems that would require further investigation include: (1) the possibility of developing accurate and acceptable carcass grade standards; (2) the most practical and desirable method of identifying, weighing and grading hogs; (3) the effect of delayed settlement on producers; (4) the most acceptable way to deal with shrinkage, bruising and disease; (5) the practi-

cability of obtaining more complete physical by-product data; (6) the persistence of price differentials between the grades during the introductory period and after the carcass system has been entirely accepted; (7) the direct cost of marketing hogs by carcass weight and grade compared with the present live weight method of marketing; (8) the increased indirect costs to society such as: cost of reorganization of the market, costs of monopoly and costs of educating producers and meat packers.

Developing Hog Carcass Grade Standards

Tentative carcass grade standards have been published by the United States Department of Agriculture for classes of slaughter barrows and gilts and for pork cuts and miscellaneous meats. No official standards have been released, however, either for slaughter hogs or pork carcasses. The tentative specifications for pork carcasses have had only a very limited acceptance. In the absence of satisfactory live or carcass standards, hogs continue to be sold with little sorting other than for weight.

The objectives of the second main phase of this study were (1) to determine the relationship between objective measurements and characteristics of the hog carcass for butcher-type hogs marketed in Iowa; (2) to use these relationships to develop tentative objective carcass grade standards; (3) to show the relative values per 100 pounds between the various carcass grade and weight classifications.

Data were obtained on 600 hog carcasses at the Iowa Packing Company at Des Moines, Iowa in 1948. The carcass measurements including average backfat thickness, length of body, length of ham, thickness of ham, thickness of shoulder, circumference of ham and thickness of belly pocket were recorded. Each carcass was subjected to a detailed cut-out test to determine weight of the various component wholesale cuts and trimmings.

Regression analyses were applied to these data to determine which measures could best be used to estimate the weight of the four lean cuts (hams, loins, picnics and Boston cuts) in the carcass. Average backfat thickness, carcass weight and length of carcass proved to be the significant measurements. The estimated weight of the four lean cuts was divided by the carcass weight to determine the per cent that these cuts were of the carcass weight. This percentage was called the "index of lean."

On the basis of this analysis a table was prepared showing the necessary back-

TABLE 1

HOG CARCASS GRADE STANDARD BASED ON BACKFAT THICKNESS, LENGTH AND WEIGHT OF CARCASS, WITH FOUR-POINT RANGE IN INDEX OF LEAN PER GRADE AND WITH GRADE 10 CENTERED AT INDEX OF LEAN OF 50.0

Carcass weights (lbs.)	Equivalent live weight (approx.) (lbs.)	Length of carcass (in.)	Carcass grades					
			8*	9†	10‡	10‡	11§	12||
			Backfat thickness at margin (in.)	Backfat thickness at margin (in.)	Backfat thickness at margin (in.)	Backfat thickness at margin (in.)	Backfat thickness at margin (in.)	Backfat thickness at margin (in.)
100-120.....	151-178	Less than 26 26 to 27.9 28 and over	2.01 2.08 2.16	1.63 1.70 1.77	1.24 1.32 1.39	1.24 1.32 1.39	.86 .93 1.00	
120-140.....	178-205	Less than 27 27 to 28.9 29 and over	2.12 2.18 2.25	1.70 1.76 1.83	1.28 1.35 1.41	1.28 1.35 1.41	.86 .93 1.00	
140-160.....	205-231	Less than 28 28 to 29.9 30 and over	2.20 2.26 2.33	1.76 1.82 1.88	1.31 1.38 1.44	1.31 1.38 1.44	.87 .93 .99	
160-180.....	231-257	Less than 29 29 to 30.9 31 and over	2.28 2.34 2.39	1.81 1.87 1.92	1.34 1.40 1.46	1.34 1.40 1.46	.87 .93 .99	
180-200.....	257-283	Less than 30 30 to 31.9 32 and over	2.34 2.40 2.45	1.86 1.91 1.96	1.37 1.42 1.47	1.37 1.42 1.47	.88 .93 .98	
200-220.....	283-309	Less than 31 31 to 32.9 33 and over	2.40 2.45 2.50	1.90 1.95 2.00	1.39 1.44 1.49	1.39 1.44 1.49	.88 .93 .98	

§ Average index of lean equals 54

|| Average index of lean equals 58

* Average index of lean equals 42

† Average index of lean equals 46

‡ Average index of lean equals 50

fat thickness for continuous gradations in the weight and length of the carcass and the index of lean. Two suggested carcass grade standards were prepared by combining carcass weights, lengths and backfat thicknesses into weight and grade groups. The limits of the grades were based on constant and equal intervals of index of lean for all carcass weight groups. A summary version of this table is shown below.

The relationship between each of the components of hog carcass and the index of lean was determined. With a given index of lean and a schedule of prices for the various wholesale cuts and trimmings, the value of the average carcass of each grade and carcass weight group can be readily determined.

Within each grade the heavier carcasses are discounted because the heavier cuts that these carcasses yield usually sell at lower prices in the wholesale trade. Price data on discounts of cuts due to inferior quality were not available; therefore, the discounts for underfinished carcasses are indeterminant.

The economic significance of carcass standards depends upon the differences in carcass value between the several weight and grade groupings. These value differences will depend on the average composition of the carcass in each of these

groupings and the relative prices of the several wholesale cuts and trimmings. The greater the price differential between the lard and lean cuts, the greater will be the discount for the overfinished grades. Likewise the greater the discounts for heavy weight cuts the greater will be the discounts for heavier weights of carcasses.

The proposed grade standards could be used in the modern packing plant to classify hog carcasses into homogeneous economic groups within each weight group. But there are limitations to the analysis. First, the distribution of the universe of hog carcasses is subject to seasonal and geographic variations. Second, there are differences in the cutting procedure for different packing plants. These differences would affect the relationships between the carcass measurements, the index of lean and the weights of the wholesale cuts and trimmings. Third, knowledge of the discounts of cuts for lack of quality should be determined. Finally, no data were collected on the value of by-products for different grades.

Additional samples should be analyzed to determine the variation between the physical relationships found in this study and samples in other geographic areas and during other seasons of the year.

TEMPERATURE AND RELATIVE HUMIDITY AS FACTORS IN THE ECOLOGY OF *LIPOSCELIS DIVINATORIUS* (MÜLLER) (CORRODENTIA, ATROPIDAE)¹

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Liposcelis divinatorius (Müller) has been reported as a pest of stored grain, grain products, and dwellings in almost all states of the United States and in several foreign countries. Although there are many published references on the damage done by this insect, the opinion is quite general among economic entomologists

that this species should be considered only as a minor pest. Much of the damage attributed to the book-louse is probably caused by cockroaches and silverfish.

Practically no specific information on the physical ecology of the book-louse is available in the literature. This investigation was initiated for the purpose of obtaining exact information on the effects of different combinations of temperature and relative humidity on certain fundamental phases of the bionomics of this insect.

Detailed oviposition studies were carried out with a series of 20 females caged and observed separately at each of

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25 different combinations of temperature and relative humidity. The results show that both factors have definite effects on the oviposition of this species. The largest number of eggs produced by 20 females in a 30-day period was 204 at 25°C. and 85 per cent relative humidity. The number of eggs laid decreased as the relative humidity decreased at all five temperature levels. No eggs were laid at either 45 per cent or 55 per cent relative humidity, except at 30°C. At this temperature 20 females laid a total of 6 eggs in 30 days at 55 per cent relative humidity, while at 45 per cent relative humidity 20 females laid only 3 eggs in the same period.

The second phase of this investigation was concerned with the effects of the different combinations of temperature and relative humidity on incubation of the eggs. The longest period of time required for incubation was 26 days at 85 per cent relative humidity and a temperature of 20°C. The incubation time decreased quite consistently as the relative humidity decreased, and also as the temperature increased from 20°C. to 30°C. However, there was little change in the length of the incubation period between 30°C. and 35°C. At 40°C. only a few eggs hatched, regardless of the relative humidity.

The incubation data fit the thermal constant velocity-of-development theory quite closely. Although incubation was more rapid at the lower humidities, the total accumulation of effective day-degrees was larger at 45 and 55 per cent relative humidities because of a lower threshold of development at these levels.

The third phase of the work dealt with nymphal development. A series of 20 nymphs in each of 20 different combinations of temperature and relative humidity was reared individually to determine the length of time required by each individual to complete its development to the adult stage. The longest time required by any nymph to complete its development was 95 days at 25°C. and 65 per cent relative humidity. The shortest nymphal life recorded was 9 days at 30°C. and a relative humidity of 85 per cent. No nymphs completed the first instar at 40°C., regardless of the humidity level. Newly-hatched

nymphs subjected to either 45 per cent or 55 per cent relative humidity were unable to reach the second instar at any of the temperatures tried.

A fourth phase was devoted to a study of adult longevity. Records were obtained of the effects of the various combinations of temperature and relative humidity on the longevity of *Liposcelis divinatorius* adults. The individuals kept at 20°C. and a relative humidity of 85 per cent lived longer, on the average, than the insects held at any other combination of temperature and relative humidity. However, the longest period a single individual lived was 108 days at 25°C. and a relative humidity of 85 per cent. The longevity of the adults subjected to 40°C. was reduced to only a few days at all five humidity levels. Also those confined to both the 45 per cent and 55 per cent relative humidity levels lived only a few days, regardless of temperature.

An experiment was conducted to determine the effect of an inert abrasive on the mortality of *Liposcelis divinatorius* adults. A small amount of Pyrax ABB was added to the food and the insects were subjected to 35°C. at three different humidity levels. At the end of a 48-hour period 100 per cent, 72 per cent, and 8 per cent of these insects were dead at 65 per cent, 75 per cent, and 85 per cent relative humidities, respectively. This and the other longevity data point to desiccation as the important factor causing death.

The adverse effects of high temperature and low relative humidities on this insect shown by the present study provide an experimental basis for some common statements. First, that populations of the common book-louse characteristically go down during the winter months in well-heated buildings. Second, that new fire-proof buildings are sometimes overrun with psocids soon after occupancy because of excess moisture remaining in the walls and floors. Third, that heating an infested building to about 125°F. is an effective control measure for this insect. Fourth, that desiccation may be an important factor limiting the populations of some insects which normally live in dry habitats and feed on dry foods.

ACIDULATION CHARACTERISTICS OF VARIOUS ROCK PHOSPHATES¹

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Phosphatic fertilizers used in the Midwestern states are now made largely from phosphate deposits in Florida and Tennessee. However, the major reserves of rock phosphate are found in the western states. Since the Midwest lies nearer the western deposits, it is of interest to investigate the possible wider use of the western deposits in this area.

The three western rocks studied were from the Fort Hall, Idaho mine of the Simplot Fertilizer Company, the Conda, Idaho mine of the Anaconda Copper Mining Company, and an Idaho mine supplying the Permanente Metals Corporation. These rocks contained 31.6, 31.2, and 29.7 per cent P_2O_5 , respectively. Control experiments were made with Florida Land pebble, which is now in commercial use, from the Mulberry, Florida deposits of the International Minerals and Chemicals Corporation containing 32.5 per cent P_2O_5 .

The acidulation characteristics of each rock were determined by mixing each rock with both 71.2 per cent H_2SO_4 and 70.0 per cent H_3PO_4 over the complete range of acidulation. After curing at 75°F. for 30 days it was found that the western rocks require, in the order listed above, 4.0, 10.0 and 15.8 per cent greater sulfuric acid acidulation than the Florida rock to give 95 per cent conversion of the P_2O_5 to an available form. To attain 95 per cent conversion with 70.0 per cent H_3PO_4 , the western rocks require 4.0, 6.7 and 16.9 per cent greater acidulation than the Florida rock.

Studies on the effect of acid concentration indicate better conversion with 60.0 per cent H_2SO_4 than with 71.2 or 80.0

per cent on all rocks. When acidulated with orthophosphoric acid all rocks studies gave maximum conversion at acid concentrations between 68 and 70 per cent.

Laboratory tests of the reaction rates between the phosphate rocks and acid indicate normal superphosphate can be mixed in a continuous conical mixer using 62.2 to 53.7 per cent H_2SO_4 . Heating the acid to 200°F. allows for faster reaction and shorter setting up time. Because of the long fluid time encountered a den would probably be necessary.

The fluid times determined for triple superphosphate were all of long enough duration to indicate possible use of a continuous conical mixer, yet sufficiently short to permit setting up on a belt conveyor. Increased acid concentrations and temperatures decreased fluid time.

Acid temperatures and curing temperatures between 75 and 150°F. had little effect on conversion in normal superphosphate. In triple superphosphate elevated temperatures as encountered in storage curing piles produced a marked decrease in conversion on the four rocks.

The superphosphates made from western rocks with either acid in the practical range showed no more tendency to cake than did those from Florida rock.

Work of other investigators has shown that the formation of dicalcium phosphate from partially acidulated rock phosphate is favored at elevated temperatures and pressures in the presence of moisture. Attempts were made to find a material which could be added to partially acidulated rock to hold the necessary moisture at elevated temperatures and atmospheric pressure. The mixtures were heated in a dry atmosphere up to 400°C. and in superheated steam at 175°C. Small beneficial effects were obtained in some cases. The addition of magnesium silicates produces a fertilizer having superior physical properties. Water solubility of the P_2O_5 content was markedly reduced, however.

1 a. Chairman of Committee, G. L. Bridger, Professor, Dept. of Chemical Engineering, Engineering Experiment Station, Institute for Atomic Research.

b. Doctoral Thesis No. 1081. Submitted July 11, 1950.

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INDOLE-3-ACETIC ACIDS AND 2-CARBOXYINDOLE-3-ACETIC ACIDS WITH SUBSTITUENTS IN THE BENZENE RING¹

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The substituted indole-3-acetic acids are worthy of investigation as possible indole-3-acetic acid antagonists and as more difficultly catabolizable analogs of indole-3-acetic acid. The chloro derivatives are of special interest, since preliminary Pea Tests have shown that the chloro-substituted 2-methylindole-3-acetic acids are more active than 2-methylindole-3-acetic acid itself.³

The synthesis of indole-3-acetic acid by an inexpensive conversion of glutamic acid has been previously noted³ but the conditions employed at the time did not give satisfactorily reproducible results.⁴ This process has been brought under control and extended to include several substituted indole-3-acetic acids in addition to indole-3-acetic acid itself.

The substituted indole-3-acetic acids prepared by this method include the 5-chloroindole-3-acetic acid, m.p. 158-159° (dec.), 6-chloroindole-3-acetic acid, m.p. 187-188° (dec.), 7-chloroindole-3-acetic acid, m.p. 164-165° (dec.), 5,7-dichloroindole-3-acetic acid, m.p. 194-197°, and the 5-methylindole-3-acetic acid, m.p. 151-152°. An eutectic mixture, m.p. 158-159° (dec.), of the 4-chloroindole-3-acetic acid and 6-chloroindole-3-acetic acid was obtained along with a small amount of 6-chloroindole-3-acetic acid by cyclization of succinaldehydic acid *m*-chlorophenylhydrazone, m.p. 101-102°. The components of the eutectic mixture were identified by Dr. A. I. Snow of Iowa State College who compared the X-ray diffraction patterns of the eutectic mixture and of the two pure components. The eutectic mixture contained approximately

twice as much of the 6-derivative as it did of the 4-chloroindole-3-acetic acid.

In order to establish the identity of the eutectic mixture and of the 6-chloroindole-3-acetic acid obtained by cyclization of the *m*-chlorophenylhydrazone it was necessary to synthesize both the 4-chloroindole-3-acetic acid and the 6-chloroindole-3-acetic acid by unambiguous methods. Both of these acids were prepared by condensation of the corresponding chloroindolylmagnesium iodides with chloroacetonitrile with subsequent hydrolysis of the resulting nitriles to the acids. The 4-chloroindole-3-acetic acid melted 185-186° (dec.), and the 6-chloroindole-3-acetic acid was found to be identical with the product obtained in low yield from the cyclization of the *m*-chlorophenylhydrazone.

In addition to the succinaldehydic acid formed in the decomposition of the α -N-chloroaminoglutaric acid there was also formed a small amount of α -ketoglutaric acid. A mechanism embracing the formation of the α -ketoglutaric acid along with the principal product from the decomposition of the α -N-chloroaminoglutaric acid has been proposed.

The α -ketoglutaric acid phenylhydrazones were isolated along with the principal product, and cyclization of these by-products gave several of the substituted 2-carboxyindole-3-acetic acid derivatives. The α -ketoglutaric acid phenylhydrazones were also obtained as their diethyl esters by the Japp-Klingemann reaction between ethyl α -acetoglutarate and phenyldiazonium salts. By the use of either one or both of these methods for the preparation of the intermediate α -ketoglutaric acid phenylhydrazones, several of the 2-carboxyindole-3-acetic acids were obtained. These included the 5-methyl-2-carboxyindole-3-acetic acid, m.p. 243° (dec.), 7-methyl-2-carboxyindole-3-acetic acid, m.p. 228-229° (dec.), 7-chloro-2-carboxyindole-3-acetic acid, m.p. 253° (dec.), 5-bromo-2-carboxyindole-3-acetic acid, m.p. 247-248° (dec.), as well as the parent 2-carboxyindole-3-acetic acid, m.p. 236° (dec.).⁵

The intermediate α -ketoglutaric acid

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b. Doctoral Thesis No. 1127. Submitted December 11, 1950.

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3 Stevens and Fox, *J. Am. Chem. Soc.*, **70**, 2263 (1948).

4 *Ibid.*

5 Kogl and Kostermans, *Z. Physiol. Chem.*, **225**, 201 (1948).

6 King and L'Ecuyer, *J. Chem. Soc.*, 1901-05 (1934).

phenylhydrazones which were purified and characterized prior to cyclization included the α -ketoglutaric acid *o*-chlorophenylhydrazone, m.p. 191° (dec.), the α -ketoglutaric acid *m*-chlorophenylhydrazone, m.p. 182° (dec.), and the α -ketoglutaric acid 2,4-dichlorophenylhydrazone, m.p. 223-224° (dec.). No attempt was made to cyclize the meta-substituted derivative and an attempt to cyclize the 2,4-dichlorophenylhydrazone was unsuccessful.

An alternate synthesis of indole-3-acetic acid and derivatives with substituents in the benzene ring has been described. This method employs ethyl γ,γ -dimethoxybutyrate in lieu of glutamic acid as a source of the intermediate succinaldehydic acid. The formation of the phenylhydrazone from the acetal and the cyclization of the phenylhydrazone to the ethyl in-

dole-3-acetate is carried out in one operation with an appreciable saving of time. Indole-3-acetic acid and 5-fluoroindole-3-acetic acid, m.p. 138-140°, have been prepared by this method, and the results indicate that the method is of very general application.

The hormonal activity of the halogen substituted indole-3-acetic acids was determined by the West Pea Test.⁷ It was observed that all of the monochloro derivatives and the 5-fluoroindole-3-acetic acid had approximately the same activity as the parent indole-3-acetic acid, while the 5,7-dichloro derivative was less active. The 2-carboxyindole-3-acetic acid was observed to have no measurable activity.

⁷ Went and Thimann, "Phytohormones," Macmillan Company, New York, N. Y., 1937.

EFFECTIVENESS OF TUTORING AID FOR POTENTIALLY DEFICIENT STUDENTS IN A MATHEMATICS OF FINANCE COURSE AT DRAKE UNIVERSITY¹

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The two semesters' work in mathematics required of Commerce College students at Drake University is the source of great difficulty for many students. The first semester course, Mathematics 14, covers elementary work through simple algebra, preparatory to the second course, Mathematics 15. The latter course deals with fairly complex problems of finance such as bonds, sinking funds, and amortization, all from viewpoints of both the investor and creditor. Many commerce students have little background or aptitude for the work, and mortality in the courses has been exceedingly high. Too, the work of the first course is of such an elementary nature that students of superior background and ability are seldom challenged.

A comprehensive study of the foregoing problem involved many research techniques and a variety of statistical treat-

ments. A discussion of the approach and method used was the purpose of this study.

Of first concern was the development of a predictive scheme for classifying potentially deficient and superior students in Mathematics 14. A predictive test was developed as part of the scheme, consisting of simple arithmetical examples and stated problems, simple algebraic equations, and functional relationships. Preliminary administration of a similar test provided valuable information for determining items to include in the predictive test. Scores were developed for each student in two forms: X'_1 , a total score; and X_1 , a partial score, which did not include results of that section of the test involving algebra.

A regression equation was then developed using X_1 as one of the independent variables. There were 118 students enrolled in Mathematics 14 in the fall of 1949 for whom needed data were available for this part of the study. Other independent variables, selected from readily available records, were the ACE Q-score X_2 , the ACE L-score X_3 , and the high school graduating class percentile rank X_4 . Dependent variable Y was a weighted

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b. Doctoral Thesis No. 1107. Submitted August 22, 1950.

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examination score developed from departmental examinations in Mathematics 14, the criterion-of-achievement in the course.

Each of the foregoing independent variables was deleted in turn from the respective regression combination, beginning with X_4 out of the combination of the four variables X_1, X_2, X_3, X_4 . The loss due to such deletion was tested and found to be non-significant only in the case of X_3 . The resulting best combination of variables gave the equation, deviation form:

$$y_e = 10.24862289x_1 + 2.04695186x_2 \\ + .84474443x_3$$

where y_e is the estimate of y . The multiple correlation coefficient's value was .661.

Development of such a regression equation at the beginning of the study was impossible because of the lack of a criterion-of-achievement variable. Consequently, in order to move ahead with aid to students in Mathematics 14 and to provide a basis for evaluating such aid, an experiment was set up involving the predictive test alone. This experiment involved only predicted low-achievement students, for a critical review of the predictive-test results gave little basis for classifying any student as potentially superior.

Since the predictive-test partial score did not include work in algebra and many of the students in Mathematics 14 lacked background in algebra, the partial score was used as the criterion of potential deficiency. The potentially deficient students were already enrolled in the seven sections of the course, when the predictive test was administered. Random selection of the predicted low students was made from the seven sections, 33 students assigned to the experimental group and 33 students to the control group. The experimental group received approximately two hours per week of regular review work under student tutors. The control group received the usual treatment afforded Mathematics 14 students, which included access to the five instructors involved for assistance. Despite efforts to maintain enrollment, by the end of the semester the number of students for whom complete data were available dropped to 16 experimental students and 17 control students.

Despite the small number of students with data available for analysis and the likelihood of indecisive results, statistical analysis was developed. Since unequal frequencies existed in the subclasses of the experimental design, covariance analysis

as developed by Tsao³ was used. Under the assumption of expected equal frequencies in the subclasses of the population, which assumption was tested, this procedure gave an approximate solution to the problem. The weighted examination score Y , was used again as the criterion of achievement in Mathematics 14. The mean of the experimental-group weighted-examination scores was 141.87 compared favorably to a mean value of 130.11 for the control group. With control on variables X_1, X_2 , and X_3 as was indicated by the previous work in regression, however, this difference proved to be of no significance. Despite the lack of statistical significance in the difference between the groups receiving and not receiving tutoring aid, any conclusion of ineffectiveness of such aid must be withheld pending an experiment with larger groups than were available in this study.

A continuing appraisal of the predictive scheme would be desirable in an effort to secure maximum ability of the scheme to differentiate potentially deficient students or potentially superior students. Following are some of the techniques used and conclusions reached in attempting such evaluation:

(1) Biserial r 's computed for each item of the predictive test using Mathematics 14 achievement criterion and response tendency, "right" or "wrong," gave an indication of the contribution of each item.

(2) A rather high degree of relationship existed between the predictive-test total score and the tendency to succeed in Mathematics 14 as indicated by a biserial r value of .733.

(3) Not only did a regression equation involving the predictive-test total score, as opposed to the one involving the partial score, predict more accurately for low achievement students, but also more accurately for all students as shown by the higher R value of .737.

(4) The regression equation involving the predictive-test total score did not predict significantly more effectively for high achievement students than did the one involving the partial score.

(5) Prediction within the group of students was less effective, but not

3 Tsao, Fel. General solution of the analysis of variance and co-variance in the case of unequal or disproportionate numbers of observations in the subclasses. p. 43-51. Unpublished Ph.D. Thesis. Minneapolis, Minnesota, University of Minnesota Library, 1945.

significantly, than within the remaining group.

(6) At least an ordinary degree of relationship existed between Mathematics 14 achievement and achievement in Mathematics 18, tending to give some justification to efforts to aid students in the basic work in the hope of eventual success in Mathematics 15.

From the foregoing account, the two ensuing inferences seemed warranted with respect to introductory courses in

mathematics of finance. Potentially deficient students may be predicted with a degree of accuracy justifying the time, effort and expense of such prediction in student personnel routine. Student tutorial aid probably is effective but lack of a significant difference, with the small group of available students, suggests the possibility of exploring other teaching procedures, such as changing from a three to a four-hour course, for potentially deficient students.

SEPARATION OF MENTHOL FROM MINT OILS BY FRACTIONAL DISTILLATION AND BY CHROMATOGRAPHIC ADSORPTION¹

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The traditional method of producing natural menthol is to crystallize it from Brazilian, Chinese, or Japanese mint oil by freezing. The average yield of menthol depends on the composition of the mint oil and is usually only 40 to 50 per cent. The mother liquor after crystallization still contains about 50 per cent of menthol and is sold as dementholized mint oil at a price about 25 per cent of that of menthol crystals. The purpose of this investigation was to find a more efficient method to separate menthol from mint oils so that a higher yield may be obtained and mint oil of low menthol content may also be used as raw material. In this endeavor, two different methods were investigated; namely fractional distillation and chromatographic adsorption.

In the fractional distillation studies, 1-menthol of U. S. Pharmacopoeia specification was isolated from mint oil by precise laboratory fractional under an absolute pressure of 20 mm. of mercury. However, by a single fractionation in a column having 50 theoretical plates and using a reflux ratio of about 50, only a small portion of the menthol distillate met the U. S. P. prescribed melting point and

refractionation was necessary to raise the melting point of the majority of the menthol fractions. Since straight distillation involved greater losses, the following process was suggested. Mentone and lower boiling fractions in the mint oil were first removed by precise distillation. Crude menthol in the residue was then separated from the resins by steam distillation. By digestion with water, U. S. P. menthol was obtained and the yield was about 85 per cent based on the menthol content in the original mint oil. Menthol did not decompose or racemize during the prolonged rectification and the subsequent purification. Removal of resins prior to the purification of menthol was necessary as resins inhibited the crystallization of menthol from organic solvents and lowered the yield.

In the chromatographic adsorption studies, sharp separation of menthol and menthone from mint oil was obtained. Almost quantitative yield of both may be expected in commercial operation. Among the adsorbents and eluants studied, mint oil adsorbed on 100-200 mesh activated carbon and washed successively with an 80 : 20 by volume mixture of Skellysolve D : carbon tetrachloride, pure carbon tetrachloride, and then carbon tetrachloride containing 10 per cent by volume of methanol was found satisfactory. Both products were unaltered by the adsorption. The effects of initial concentration of solution, adsorbate to adsorbent ratio, rate of development of the chromatogram, particle size of adsorbent, length to diameter ratio of the adsorption

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column, and menthol to menthone ratio in the oil on the sharpness of separation of this particular menthol-menthone system were studied.

Two new processes to separate menthol from mint oils by fractional distillation and by chromatographic adsorption were proposed. A preliminary economic analy-

sis indicated that both processes can compete favorably with the traditional crystallization process and the recently developed boric acid method. The chromatographic adsorption method seems to have greatest promise because of its high yield.

SOME FACTORS AFFECTING THE EMULSIFYING PROPERTIES OF HEN'S EGG¹

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The utilization of waste materials has become a necessary part of successful industrial operations. In the poultry industry the abundance of such materials, specifically inedible eggs from breaking and freezing plants, hatcheries, and cold storage, has established the need for by-product development. Such development is generally undertaken through the concentration or isolation from the waste material of some factor which has a unique and valuable property. The ability to emulsify oils is one such property in whole egg and this ability is used extensively at present in the food industry. Some use is also found in the leather industry (for the inedible eggs); however, the unreliability of the product had reduced even this limited demand. This study was directed toward the development of a test for measuring emulsifying ability, the isolation of the emulsifying components from whole egg, and an investigation of the effects of processing treatments on the emulsifying ability of these components.

All egg preparations to be tested for emulsifying ability were made up to the same composition with respect to non-fat-solids, oil, water, salt, sugar, and acetic acid. The prepared emulsifier was then used to emulsify a large quantity of corn oil (the finished emulsion contained

about 70 per cent oil) by a procedure that was a quantitative adaptation of the usual commercial method of making mayonnaise. The viscosity of the completed emulsion at five different emulsifier concentrations was then measured. From these viscosity measurements an emulsifying index was determined. Upon critical evaluation of the data, it appeared that the emulsifying index was influenced by the initial viscosity of the emulsifier as well as the emulsifying ability. It was thus felt that some criterion for emulsification such as oil globule size distribution or emulsion stability would have more accurately estimated the emulsifying ability than did the measurement of emulsion viscosity.

Spray dried whole egg and fresh egg yolk fractions were prepared. The ether insoluble portion (the "protein" and "lipoprotein" portion) was the principal emulsifying substance in whole egg. The ether soluble egg lipids showed no emulsifying ability under the test conditions; however, the acetone insoluble lipids (presumably the phospholipids) were able to emulsify to a slight extent. When added to the ether insoluble portion, the "phospholipids" reduced its emulsifying ability.

Of the "proteins" of yolk (the ether insoluble substances) the water insoluble portion (the "lipoproteins") possessed considerable emulsifying ability compared with the water soluble portion (the "livetins"). However, when the latter was added back to the "lipoproteins" in natural proportions, the mixture exhibited an emulsifying ability equal to that of the "lipoproteins" themselves.

- 1 a. Chairman of Committee, George F. Stewart, Professor, Dept. of Chemistry, Associate Director of Agricultural Experiment Station.
- b. Doctoral Thesis No. 1163. Submitted May 23, 1951.
- 2 a. B.S., Michigan State College, East Lansing, Michigan, 1947.
- b. Graduate Assistant Agricultural Experiment Station.

Fresh egg albumen that had been dried by lyophilization was an excellent emulsifier. It thus appeared that the emulsifying ability of the ether insoluble portion of whole egg was due primarily to the three main protein constituents (albumen, "lipoprotein," and "livetin"). The possibility of interaction between albumen and yolk proteins, however, was not investigated in these experiments.

The selection of a process for production of an emulsifier for whole egg depends for the most part upon three factors, the quality of the emulsifier, the yield of emulsifier, and the cost of production. The use of supercentrifugation was rejected as a commercial procedure because of the low yield of emulsifier (30 per cent of the ether insoluble solids).

Six extraction methods for the preparation of an emulsifier were compared. These methods included spray drying and extraction, spray drying of salted egg and extraction, spray drying of sugared egg and extraction, extraction of liquid egg and spray drying, extraction of salted egg and spray drying, and extraction of sugared egg and spray drying. No differences in the emulsifying ability of the products were found among these processes and the yields were similar; however, since the cost of a liquid-liquid extraction exceeds that of a liquid-powder extraction, the latter method was chosen for further study.

The effect of processing treatments upon the emulsifying ability of liquid whole egg and the trichloroethylene insoluble portion of spray dried whole egg was studied. These processes included homogenization, freezing, vacuum drying at low temperatures, and spray drying of whole egg; extraction of whole egg powder at 18°C. to 21°C. (65°F. to 70°F.) and at 71°C. to 77°C. (160°F. to 171°F.); and extraction of the trichloroethylene, extracted powder. The effect of addition of the extracted sub-

stances back to the residue was also studied.

Homogenization appeared to decrease the emulsifying ability of whole egg; however, this ability increased markedly during frozen storage to a level equal to that of the unhomogenized and frozen control. Freezing of unhomogenized whole egg had little effect on the emulsifying ability. A small increase (after about 30 days), which was unaffected by the addition of salt prior to freezing, was brought about by the frozen storage.

Vacuum concentration and drying (at 28°C., 82°F.) decreased the emulsifying ability of whole egg. Spray drying, however, appeared to increase the emulsifying ability of both extracted and unextracted whole egg.

Extraction of spray dried whole egg at the lower temperatures increased the emulsifying ability of the powder markedly. This increase was more pronounced at the higher temperatures of extraction. Trichloroethylene was unable to reduce the fat content of the powders below about 10 per cent and ethyl alcohol was used to remove this fat (to about 1.5 per cent). The alcohol extraction reduced the emulsifying ability of the powder.

Dry heat increased the emulsifying ability of spray dried whole egg. This result explained in part the effects of spray drying and extraction at higher temperatures on the emulsifying properties of egg. Trichloroethylene and ether soluble egg lipids reduced the emulsifying ability of the emulsifier more than an equal amount of corn oil. It was concluded that the effect of high temperature extractions on the emulsifying ability of whole egg could be ascribed in part to the removal of a substance (probably phospholipid in nature) specifically inhibiting the emulsifying action of the whole egg and to the effect of dry heat *per se*.

PHYSIOLOGICAL STUDIES WITH CRESTED WHEATGRASS¹

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A major objective of range and pasture management is the greatest sustained yield of high nutrient forage. To attain this objective requires first, a fundamental knowledge of the growth characteristics of the undisturbed forage plants, and second, an understanding of the effects of grazing at various seasons and intensities upon the total yield, forage composition and plant vigor. Studies of this nature have been largely concentrated upon forage plants adapted to humid areas where pasture management is more intensive. Limited investigations have been conducted with plants which are adapted to the semiarid conditions characterizing the range lands of western United States.

The present study was concerned with crested wheatgrass, a cool season long-lived bunch grass, native to the cold dry plains of Russia and Siberia. This grass is recognized as the most successful introduced species for reseeding abandoned farm and deteriorated range lands in the northern parts of the great plains and intermountain region. The work was conducted in 1948 and 1949 at the Belle Fourche, Bureau of Plant Industry Experiment Station located near Newell in northwestern South Dakota. Plots were located on a well established stand of crested wheatgrass planted in the spring of 1942. The object was to investigate the response of crested wheatgrass to clipping treatments from the standpoint of (a) total yield and composition of forage and (b) the maintenance of plant vigor as indicated by root development and reserves.

Under dry land conditions, crested wheatgrass plants clipped to 3 inches at monthly intervals for two consecutive years gave total yields at the end of the second year which were 50 per cent lower than unclipped plants. Plants clipped to 1 inch biweekly during the same period produced 25 per cent as much as un-

clipped plants. The growth habit of this bunch grass does not permit it to withstand the close clipping tolerated by plants capable of a more prostrate growth. Plants clipped to 1 inch were markedly reduced in density at the end of the second growing season, while stand density was maintained where plants were clipped to 3 inches.

Irrigated plots of crested wheatgrass clipped only once during the growing season at a specific stage of development gave lowest yields for plants clipped during the shoot stage. Removal of leaf area with resultant reduction of photosynthetic materials for growth during the most favorable growing season is believed to be the primary cause of this reduced yield. Highest total yields were obtained from plants clipped at maturity, but reduced palatability offset this yield advantage.

Forage composition determinations showed that higher sugar, water soluble polysaccharides and protein content were maintained in clipped plants until later in the summer and fall than in unclipped plants, indicating a desirable grazing system would be one which prevents a large part of the plants from forming seed.

In unclipped plants, total sugars and water soluble polysaccharides increased to the dough stage and declined following seed maturity. Total sugars and water soluble polysaccharides in clipped plants not developing seed were highest during drought dormancy and at the end of the growing season. Sugar accumulation in clipped plants resulted from limited moisture and low temperature rather than physiological maturity.

Clipped plants were higher in protein than unclipped plants at all stages following anthesis. Plants clipped to 1 inch were higher in protein than plants clipped to 3 inches. Factors other than relative physiological maturity are indicated. Reduced transpiration and growth resulted in more available moisture and soil nitrogen on the closely clipped plots.

In July of the second year of clipping treatments, root yields of crested wheatgrass clipped to 3 inches were 52 per cent

1 a. Chairman of Committee, W. E. Loomis, Professor, Dept. of Botany, Agricultural Experiment Station.

b. Doctoral Thesis No. 1089. Submitted July 14, 1950.

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as much as root yields from unclipped plants, while plants clipped to 1 inch were reduced to 28 per cent of the unclipped plants. Reduction of roots at lower soil levels with increased intensity of clipping was not pronounced. Moisture data taken at the time of root sampling showed a greater percentage of moisture at deeper levels under the severely clipped plants. This soil moisture condition made it possible for roots of closely clipped plants which were at deeper levels to compete with roots nearer the surface regardless of the relative distance from the carbohydrate source.

Weak growth of closely clipped plants during the early spring months of the second year indicated the importance of an abundant root reserve for rapid growth during the cool spring season when crested wheatgrass is most valuable. Total sugars in the roots of unclipped plants for the stages sampled were lowest during the dough stage, and highest following seed maturity. Depletion and accumulation of reserves followed similar trends in clipped and unclipped plants. However, the physiological maturity features characteristic of unclipped plants were absent for clipped plants not forming seed. Data indicated that root reserves were depleted during periods of active vegetative growth while reserves accumulated under growing con-

ditions which checked top development. Root reserves decreased as the intensity of clipping increased.

Reducing sugars increased during active growth and during the dormant winter season, indicating the mobility of this form. Sucrose appeared to be the first form of storage and utilization, followed by water soluble polysaccharides which were more abundant than either of the sugars. Nitrogen was highest in the roots in the spring and fall, when soil moisture and nitrogen were more available and new leaf growth was being produced. The soluble form increased during the post growing season.

The ability of crested wheatgrass to accumulate reserves rapidly during the fall regrowth period at the end of the second year of severe clipping, suggests photoperiod responses, and demonstrates the resistance of this species of heavy grazing.

Root analysis of etiolated plants grown under light-tight ventilated boxes indicated that sugars, nitrogen, water soluble and part of the acid hydrolyzable polysaccharides were utilizable reserves. The acid hydrolyzable material was not utilized as much in unclipped plants as in clipped, suggesting a more complex form in the unclipped plants. A more specific fractionation would have been desirable.

THORIUM-CARBON SYSTEM¹

PREMO CHIOTTI²

Department of Chemistry

A study of the thorium-carbon system has been made and a tentative phase diagram constructed from metallographic, X-ray, and melting point data.

The existence of two compounds, ThC (4.92 per cent carbon) and ThC₂ (9.38 per cent carbon), has been verified. No conclusive evidence was found for any other compound. The monocarbide has a sodium chloride-type structure, and the lattice constant for this compound is shown to be 5.34 Å. This is considerably larger

than the lattice constant previously reported for the monocarbide. It is shown that the lattice constant previously measured was that of a solid solution of thorium in thorium monocarbide. The lattice constant at room temperature for the monocarbide phase increases from 5.29 to 5.34 Å as the carbon content is increased from about 3.8 to 4.92 per cent.

The monocarbide melts at $2,625 \pm 25^\circ\text{C}$. and the dicarbide at $2,655 \pm 25^\circ\text{C}$. All compositions between thorium and the monocarbide shown complete miscibility in the liquid state and in the solid state at elevated temperatures. However, an immiscibility gap in the solid solution area appears to extend from room temperature to just under the solidus line. The peak of this gap is at about 2 per cent carbon and $1,975^\circ\text{C}$. The composition of

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the thorium-rich and carbon-rich solid solutions for this gap at room temperature are about 0.25 per cent carbon and 3.8 per cent carbon, respectively. The monocarbide and dicarbide also form a complete series of solid solutions at elevated temperatures but show little or no mutual solid solubility at room temperature. The dicarbide forms a eutectic with graphite containing approximately 12.6 per cent carbon which melts at $2,500 \pm 35^\circ\text{C}$.

A method for measuring the electrical resistance at very high temperatures is given. Automatic recording and control instruments which can be used in conjunction with this method are described. This is essentially a potentiometer method wherein the potential developed between two probes which make contact with the test piece is balanced against a potential developed across the secondary of a current transformer. The primary of the current transformer is connected in series

with the test piece. The test piece, in the form of a bar is mounted between water-cooled copper electrodes and is heated by passing a high 60 cycle current through it. The change in resistance is measured directly.

Construction details of a furnace suitable for resistance heating of test bars under vacuum or an inert atmosphere are given. This furnace was used in determining melting points and in heating samples whose change in resistance with temperature was measured up to approximately $2,600^\circ\text{C}$.

The melting points of thorium-carbon compositions containing up to 14 per cent carbon were determined. The temperature dependence of the electrical resistance of thorium and of a number of thorium-carbon compositions was measured. Evidence indicating the existence of an allotropic modification of thorium at temperatures above $1,400^\circ\text{C}$. is presented.

GENERALIZED HERMITIAN OPERATORS IN HILBERT SPACE¹

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Department of Mathematics

Consider a class C of operators in Hilbert space S in which a member X is characterized by the following conditions:

1. X^* , the adjoint of X , exists;
2. $D(X) \cdot D(X^*)$, the intersection of the domains of X and X^* , generates S ;
3. $X = X^*$ over $D(X) \cdot D(X^*)$.

Obviously all Hermitian operators (H.o.) are contained in C . It can be shown that there exist operators in C which are non-Hermitian. An operator in C is called a generalized Hermitian operator (g.H.o.). It is said to be proper if it is non-Hermitian. The contraction X' of X over $D(X) \cdot D(X^*)$ is called the Hermitian contraction of X .

It was found that X and X' are not structurally closely related. For example: if X is (closed) linear, then so is X' , but not vice versa. However, an important fact, the equality of X and X' in the

bounded linear case, was easily verified. This shows that the study of the operators in C is sensible only if they are assumed to be unbounded.

If X is a g.H.o., then X is an extension of a H.o. (i.e. X'). A natural question is whether the converse is true. We found that the answer is in the negative. Another question is: given a H.o. Z , what are those X having $X' = Z$? The following is a summary of some typical theorems which are proved relevant to the above two questions:

1. If X is a g.H.o., then \hat{X} and \tilde{X} , the least linear and closed linear (c.l.) extension of X , exist.
2. If X is a c.l. extension of a H.o. Z , $X = Z^*$ over $D(X) \cdot D(Z^*)$, and $XU Z^*$ has a c.l. extension, then X is a g.H.o. ($XU Z^*$ is the operator which coincides with X on $D(X)$ and with Z^* on $D(Z^*)$).
3. X is a g.H.o. if and only if there exists a H.o. Z , such that $Z \leq X \leq Z^*$, and than $X' \geq Z$. $X' = Z$ if and only if there exists no proper Hermitian extension Y of Z which satisfies the relation $Y \leq X \leq Y^*$ as Z does. Further, there

1 a. Chairman of Committee, Bernard Vinograd, Associate Professor, Dept. of Mathematics.
b. Doctoral Thesis No. 1139. Submitted December 14, 1950.
2 a. B. S., University of Chekiang, China, 1946.
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exists at least one non-Hermitian operator X such that $X' = Z$ for a given H.o. Z if and only if Z is not essentially self-adjoint.

The subscript "''" has some properties similar to the adjoint symbol "*". The following results are typical of the behavior of "''".

1. If X is a g.H.o., then X , X' , and X exist.

They are also g.H.o. and $X' \leq \hat{X}' \leq \tilde{X}' = X''$.

2. If X and Y are two g.H.o., then $X' + Y' \leq (X + Y)'$, and $(aX)' \geq \bar{a} X'$ hold whenever they are defined. But whether $X' \leq Y'$ is entirely independent of whether $X \leq Y$.
3. If X is a g.H.o., and X^{-1} the inverse of X , exists, and $R(X')$, the range of X' , generates S , then X^{-1} is a g.H.o. and $(X^{-1})' = (X')^{-1}$.

With regard to the matrix representations of closed linear g.H.o. (c.l.g.H.o.), we

proved the following results:

1. If X is a c.l.g.H.o., then for any positive integer n , there exists a determining set (d.s.) (ϕ_n) of X such that the matrix A , which belong to X for (ϕ_n) , and A^* , the conjugate transpose of A , have at least n equal corresponding rows. If X is proper, then for some other choices of d.s. of X , the corresponding matrices A and A^* will have at least n unequal corresponding rows. Further, there exists a g.H.o. X for which it is possible to choose a d.s. of X such that the corresponding matrices A and A^* have no equal corresponding rows.
2. A quadratic matrix (q.m.) A generates g.H.o. if and only if there exists a unitary matrix (u.m.) and U and a Hermitian quadratic matrix (H.q.m.) C such that $AU = UC$.
3. If C is a H.q.m. and U is a u.m., then $(UC)U^*$ generates g.H.o. if and only if UC is a q.m.

UTILIZATION OF NITROGEN BY THE ANIMAL ORGANISM

VI. FACTORS INFLUENCING NITROGEN RETENTION WHEN CERTAIN MIXTURES OF AMINO ACIDS ARE FED TO THE NORMAL ADULT ALBINO RAT¹

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Department of Foods and Nutrition

Eventually the protein needs of the adult animal organism will be expressed in terms of the amino acids present in its normal food supply. Tentative values indicating the quantities of the ten essential amino acids that are required for the maintenance of body weight and for the establishment of nitrogen balance in two species, i.e., the human being and the rat, have been reported in the literature. Whether or not the requirements have been expressed quantitatively is a question that may be debated, because the utilization of nitrogen from any dietary source is influenced by many varied and interlocking factors.

It has seemed to workers in the Home Economics Research Department of the Iowa Agricultural Experiment Station that a sound approach to the study of the amino acid requirements of the well-nourished albino rat could be made by observing the response of the animal to the incorporation in a balanced ration of mixtures of amino acids simulating those in a "pure" protein whose biological efficiency was well established. Lactalbumin is such a protein.

The investigation reported herein represents a critical evaluation under conditions of rigidly controlled caloric intake (force-feeding) of the nutritive efficiency of a mixture of amino acids, alike in quality and quantity to those in a diet containing just enough lactalbumin to support nitrogen equilibrium in the adult well-nourished rat. Twenty-two rations were fed to 167 rats. In judging the nutriture of the animals, nitrogen balance and nitrogen content of hepatic tissues served as indices of measurement. The

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attainment of nitrogen equilibrium was chosen as a criterion of minimal needs.

When a mixture of essential amino acids representing those in a diet containing 4 per cent of lactalbumin was fed to adult well-nourished rats as the sole source of nitrogen, a curious disorder developed. It was accompanied by a marked destruction of body tissue as reflected by a strongly negative nitrogen balance. The rats exhibited a peculiar behavior pattern, being hyperexcitable and lethargic in turn. About one-half of them died after 11 days of force-feeding.

In this experiment, the rats were force-fed twice each day, the total daily quota being 24 ml., an amount equivalent to 13 gm. of solid ration. Whether the rat was metabolizing these large portions of food successfully was questioned. In a second experiment, the same total quantity of food was administered to one group in three equal portions. Then, it was offered to another group in solid form *ad libitum*. The symptoms described above did not develop in either of these latter groups. The nitrogen balances, however, remained distinctly negative.

Other workers have described similar symptoms associated with the force-feeding of diets deficient in certain nutrients, i.e., tryptophane or thiamine. The data secured in the present investigation indicate that a disorder of this kind may represent intolerance to a large quantity of food that is nutritionally inadequate instead of a specific dietary deficiency. This factor, therefore, must be considered carefully in drawing conclusions from experiments in which force-feeding is employed.

In the next phase of the study, the effect of adding the nonessential acids to the mixture of essential acids was studied. The respective quantities of the nonessential acids in the mixture tested were equivalent to those in a control diet containing 4 per cent of a lactalbumin preparation. In this and succeeding experiments, all formulae for amino acid mixtures were based on the composition of lactalbumin as indicated by microbiological assay.*

The diet supplying only the essential acids again failed to support nitrogen equilibrium, the balance being -200 mg./300 gm. rat/7 days. However, when this mixture was supplemented with the nonessential acids, it sustained balance at the level characterizing the response induced

by feeding the lactalbumin control diet.

Thus, the importance of the nonessential acids for the attainment of nitrogen equilibrium was demonstrated when the assortment of essential acids fed was equivalent to those present in lactalbumin. To find the minimal quantity that would supplement this essential amino acid mixture successfully, graded doses of the mixture of nonessential acids were fed in conjunction with the essential acids, the daily quotas of nonessential nitrogen per rat being 10, 20, 30, 40, 50, and 60 mg. All amino acid mixtures appeared to be absorbed completely.

The regression of nitrogen balance/7 days in mg./100 sq. cm. body surface on nitrogen intake/7 days in mg./100 sq. cm. of body surface was linear ($Y = 0.8304X - 118.7$). Nitrogen equilibrium was attained when the diet provided approximately 150 mg. of nitrogen/7 days/100 sq. cm. of body surface. This was equivalent to a total intake of 83 mg. of nitrogen/300 gm. rat/day, 40 mg. of which represented nonessential nitrogen and 43 mg. essential nitrogen. A distinctly positive balance was not attained until the nonessential acids provided 50 mg. of nitrogen daily.

The dietary treatments imposed did not influence the size of the liver, dry weights of the organ being nearly the same in all test groups. The livers of rats fed a low-nitrogen diet, however, contained less total nitrogen than did those of the lactalbumin-fed rats. Supplementation of the low nitrogen diet with the essential acids induced an increment, even though the rats remained in negative balance. Further increases in hepatic nitrogen were brought about by the administration of graded doses of nonessential acids until equilibrium was attained. With the establishment of a distinctly positive balance, however, a decrease in hepatic nitrogen was observed. Apparently, the provision of sufficient quantities of nonessential nitrogen makes possible the mobilization of the element in the liver for use in some phase of protein anabolism, i.e., the synthesis of metabolites, functional proteins or structural proteins.

To ascertain whether the essential amino acids alone were as effective in maintaining nitrogen equilibrium as a mixture of essential and nonessential acids providing the same total quantity of nitrogen (83 mg./300 gm. rat/day), a diet was formulated that contained twice the amount of each essential acid present in the original mixture tested. The average nitrogen balance of rats fed this mixture

* Appreciation is expressed to Dr. Max Dunn, Professor of Chemistry, University of California, for the analysis of the specific preparation of lactalbumin used as reference material.

was -70 mg./300 gm. rat/7 days in contrast to +7 mg. when both the essential and nonessential acids were present. Evidently, at the level of dietary nitrogen fed, the adult rat is unable to meet its requirements for the essential acids and to synthesize the nonessential acids at a rate commensurate with its metabolic needs, even when the dietary supply of the latter is fairly generous.

This observation raised the question as to where the mixture of essential acids present in lactalbumin represented the most efficient combination for the support of nitrogen equilibrium. From an examination of the amino acid composition of diets known to support nitrogen equilibrium, it appeared that the quantities of methionine and phenylalanine present in a diet containing 4 per cent of lactalbumin were not optimal, and that cystine and tyrosine were playing a part in establishing the nitrogen equilibrium that accompanied the feeding of this diet. Upon test, it was found that isonitrogenous replacement of cystine with methionine, and of tyrosine with phenylalanine could be made without altering the nitrogen balance significantly. But, very interestingly, the *simultaneous* isonitrogenous substitution of the two non-essential acids with methionine and phenylalanine increased nitrogen retention significantly. Thus, nitrogen originating from these two amino acids was more efficient than the same quantity of nitrogen supplied by the four acids, methionine, phenylalanine, cystine, and tyrosine combined in the proportions in which they exist in lactalbumin.

Whether or not certain nonessential acids were of specific importance in the establishment of nitrogen balance was

studied next. Time did not permit an evaluation of the effect of the successive removal of each nonessential acid in the mixture. Therefore, the acids present were divided into groups according to their chemical classification. Each group was withdrawn in turn from the basal mixture. In this process, the total supply of nitrogen was held constant by increasing the quantities of the remaining nonessential acids. The omission of cystine resulted in marked nutritive failure as measured by nitrogen balance. The withdrawal of tyrosine depressed nitrogen balance only slightly. Glycine and alanine could be replaced by other nonessential acids without adverse effect on nitrogen balance.

In the final study, the ability of a single nonessential amino acid to supplement the composite of essential acids found in lactalbumin was tested, glutamic acid being the amino acid chosen. When it was added alone to the mixture of essential amino acids equivalent to those in a 4 per cent lactalbumin diet, the animals exhibited an acute negative balance. However, when it supplemented the mixture in which additional methionine and phenylalanine were added to replace cystine and tyrosine, respectively, the balance approximated that attained when the same composite of essential acids was fortified with a variety of nonessential acids providing the same total quantity of nitrogen. Apparently cystine and tyrosine cannot be replaced by glutamic acid, and it would seem, therefore, that glutamic acid can effectively replace complex mixtures such as naturally occur in common foods, only when methionine and phenylalanine are present in quantities adequate for the retention of nitrogen.

RESPONSE OF THE BLACK LOCUST, *ROBINIA PSEUDOACACIA* L., TO ENVIRONMENTAL FACTORS¹

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This investigation was carried out to determine the response of black locust, *Robinia pseudoacacia* L., to variations in environment in Iowa. Sample plantings

were selected to obtain the maximum range of environmental conditions.

Plantings were made by the U. S. Soil Conservation Service between the years 1935 and 1942. Plantings in seven of the southernmost tier of counties were used, starting with Davis county on the east and ending with Fremont county on the west. A discontinuous north-south series of plantings in 5 counties north of Davis county was also used. Where possible,

- 1 a. Chairman of Committee, J. M. Aikman, Professor, Dept. of Botany, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1105. Submitted August 21, 1950.
- 2 a. B. A., Colorado State College of Education, Greeley, Colorado, 1942.
M. S., Iowa State College, Ames, Iowa, 1948.

2 plantings in each county were sampled. There was a total of 21 plantings included in the investigation.

The trees were planted with a density of 1,296 to 4,900 trees per acre. The range of density of the trees surviving in 1949 was from 50 to 1,030 trees per acre. The rate of survival varied from 1 to 79 per cent.

The original spacing of the trees varied from 3 x 3 feet to 6 x 6 feet and had a significant effect on the survival rate of the plantings. The age of the plantings, when compared with the survival rate was not significant. This indicated a high early mortality in the plantings.

The physical measurements of the trees varied widely among plantings. The average tree height for all plantings was 22.4 feet, with a minimum average height of 14.4 feet and a maximum average of 41.4 feet. The d.b.h. had a range of 2.0 to 6.1 inches for all plantings and the average was 3.4 inches. The average number of 7 foot posts obtainable per tree ranged from 0.6 to 2.8 with a total average of 1.4 posts per tree.

The average annual diameter increment was used in classifying plantings as "good," "medium" and "poor." Increments varied from an average of 0.20 inch per year in the poorest plantings to 0.42 inch per year in the best site. The total average increment per year was 0.34 inch.

The point-list method was used in determining ground cover. Five classifications were used; bare ground, grass, forbs, shrubs and vines, and tree seedlings. The total averages and ranges were as follows: bare ground 73.9 per cent, 49.4 to 96.8 per cent; grass 16.6 per cent, 2.0 to 46 per cent; forbs 7.1, 0.4 to 33.0 per cent; shrubs and vines 0.3 per cent, 0.0 to 2.8 per cent; tree seedlings 0.3 per cent, 0.0 to 1.2 per cent. Grazing usually resulted in a decrease in grass cover and an increase in annual vegetation.

The factor of soil aeration is considered to be of prime importance in tree growth. The soil in each planting was sampled in 6 zones to a depth of 4 feet. The macropore space, or aeration porosity, was significantly different among the planting sites. The moisture equivalent, a measure of field capacity, was found to be significantly different among the 6 depths sampled and between sites.

Bisect studies of the root growth habits of black locust revealed that 90 per cent or more of the roots are found in the first foot of soil. Cultural planting site treatments were effective in increasing

the depth at which numerous roots were found growing.

Two of the principal climatic factors affecting the growth of black locust are precipitation and unseasonably early or late killing frosts. The third important factor, soil aeration, has been previously mentioned. Climate can be discussed on a broad geographic basis and for a long period of years with reasonable accuracy. The period of growth of the trees used for this investigation was too short for the seasonal climatic inequalities to average out completely.

The local environment is decisive in the success and failure of black locust plantings. An area which had a broad climatic and edaphic suitability may not be satisfactory for black locust. The appropriateness of the planting site must be judged on the basis of that site, not on a regional basis. Good soil structure may compensate for a small deficit in rainfall, and more than adequate rainfall might compensate for a small deficit in rainfall, and more than adequate rainfall might compensate for low water holding capacity of the soil. Differences among sites in precipitation were very small. Local topography and soil conditions compensated for site deficiencies or accentuated the deficiencies. A protected location, sheltered from hot summer winds and with a continuous passage for cold air drainage, is preferable as a planting site.

Moderate grazing does not help the growth of black locust, nor does it apparently do great harm, unless the planting site is one which could be considered "marginal."

A certain amount of borer infestation is regarded as normal in black locust plantings. A highly significant correlation between bark smoothness and freedom from borer damage was determined in this investigation. A study of the periderm of damaged and relatively undamaged trees revealed a condition of hyperplasia of the cells of the periderm in those trees which were badly damaged by borers. The factor causing the hyperplasia was shown to be active over a distance, since only sections of the stems some distance from borer holes, were used in the study.

Planting sites for black locust in southern or eastern Iowa should have the following characteristics. The macropore space should not be less than 10 per cent in the first 12 inches of soil and should be continuous for 24 to 36 inches, which facilitates drainage. The planting site should not be in a low area which is

subject to periodic flooding. The site should be sheltered, but not so located that cold air will flow in and accumulate.

The soil should have a reasonably high field capacity, but not a high wilting per cent.

GROWTH AND FRUITING OF CONCORD GRAPE¹

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Growth measurements and observations were made at three locations in a hillside vineyard at Council Bluffs, Iowa, during the period from bud break through fruit setting in 1949. Partridge (1925) found a close correlation between the measurements of the sixth internode and the fruitfulness of the canes. In our material, the sixth internode of new shoots had completed its growth in length before blossom time. Maximum diameter was attained within a week after bloom on heavily fruiting vines, but growth in diameter may continue for several weeks on vigorous, light-fruited plants. There was a tendency for the optimum diameter of fruiting canes on vigorous vines to be near 5-6 mm., while the optimum diameter for fruiting canes of weekly vegetative vines was about 7-8 mm. The length of the new shoots was closely correlated with the ultimate diameter of the sixth internode on heavily-fruited vines, $r = 0.875$; but less closely correlated on the vigorous, light-fruited ones, $r = 0.704$, where increase in diameter after fruit setting caused a lower correlation. Since no appreciable increase in shoot diameter occurs after fruit set with moderate to heavy fruiting, fruit growth is assumed to be dominant over cambial growth in competition for food.

Long shoots, 105 cm., medium shoots, 60 cm., and short shoots, 45 cm. long were sampled at blossom time and analyzed chemically. Nonreducing sugars and insoluble nitrogen were inversely related to shoot vigor, but reducing sugars and soluble nitrogen did not show any definite trends which could be related to the vigor of the shoots. The chemical composition

of the shoots at blossom time was apparently the effect rather than the cause of differences in vigor.

The tips of all leaves less than half grown were removed from the shoots of a group of vines at the beginning of bloom, and the clusters were analyzed after six days. Tip removal increased the soluble nitrogen content of the clusters, percentage berry set, weight per cluster, and yield per vine. There were also indications that reducing sugars in the clusters were increased. The highly significant increase in number of flowers setting fruit was apparently the result of an increased supply of growth material (soluble nitrogen) for the flowers. Carbohydrates, although necessary, were considered to be of secondary importance in fruit setting. The one-year wood removed from the treated vines in pruning the following winter was 0.9 per vine against 1.3 pounds per untreated vine. The rapidly growing shoot tips appeared to have a greater competing power than the flowers at blossom time, but fertilization and growth tend to increase the competing power of the fruit and it becomes dominant (cf. Loomis, 1934).

Random, 30-shoot samples were collected on June 7, three days before the beginning of bloom, during the late bloom, June 14, and ten days after bloom, June 24. These were cut into one-node sections and kept in separate groups according to the location of the node on the shoots. The axillary buds distally from the third node were removed for histological examination and the nodes used for chemical analyses.

Cluster (inflorescence) primordia of the following year were found in axillary buds of the fourth node of new grape shoots three days before bloom. The first two nodes within the bud produce leaf primordia with lateral stipules but no cluster primordia. The first cluster primordium in a Concord bud appears opposite the third leaf and undergoes

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considerable branching before the second cluster primordium begins to branch. Chemical analyses showed an apparent increase in reducing sugars in the nodes at the time of cluster primordium initiation. The development of the primordia once they have been initiated, appears to be correlated with the supply of available soluble nitrogen.

There was a very marked increase in the soluble nitrogen content of the growing, apical nodes, from .031 per cent to .076 between June 7 and June 24. Apical growth decreased with flowering and early fruiting from an average of 2.1 inches per day for the June 7-14 period to 0.6 inches per day for the June 14-24 period as fruit growth became competitive. Possibly there was a shift from the use of digested, organic nitrogen reserves on June 6, with a gradient from the old canes outward, to the synthesis of inorganic nitrogen into organic forms in the leaves at the later dates. Depletion of stored nitrogen of the roots and an increase of

nitrification in the warming soil would tend to induce such a shift.

Critical periods occur during the growing season when the food competing power of essential organs is low. Abundant nutrients from the soil, especially nitrogen and water, at these times may increase the competitive power of some organs leaving insufficient food materials available for the proper development of the essential ones. The growth and fruiting of Concord grape is, therefore, determined in considerable part by the relation of these critical growth periods to cultural practices which affect the availability of soil nutrients.

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TURNOVER OF IOWA SCHOOL SUPERINTENDENTS DURING THE PAST FORTY-FIVE YEARS AND ITS RELATION TO ECONOMIC TRENDS¹

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For many years the problem of turnover in the business world has received careful consideration. In the field of public education few studies of turnover have been made. None was found in which information was assembled over a sufficiently long period of time that long-time trends could be studied in relation to changes of economic conditions.

The present study is a description of the historical information of the turnover of superintendents in Iowa school districts maintaining high schools, beginning with the school year 1905-06 and ending with the school year of 1949-50. Information

was obtained from directories published annually by the State Department of Public Instruction.

An economic index was developed for the same period of years from available indexes of (1) cost of living, (2) wholesale prices, and (3) prices received by Iowa farmers.

The number of school districts maintaining high schools has varied from year to year with an average between 800 and 900 districts. In the 45-year period between 35,000 and 40,000 superintendent-years of service were provided for the public schools of Iowa. This administrative service was rendered by approximately 6,600 different individuals who have held more than 12,000 superintendent positions during the period studied.

The investigation, here reported, was a part of the Research Project 938 of the Vocational Education Section of the Iowa Agricultural Experiment Station.

Turnover was expressed in terms of

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percentages of schools in which a change of superintendents occurred as revealed by successive annual directories. Turnover varied from 52 per cent in 1918 to 17 per cent in 1933 with a 45-year average of 32 per cent.

Inspection of the data revealed a downward secular trend during the 45 years. The turnover series was fitted by the method of least squares with the assumption of an irreducible minimum turnover of 10 per cent by an equation of the form

$$\log (Y - 10) = aX + k$$

where Y = percentage turnover
 X = years since 1927

The equation for secular trend was found to be

$$\log (Y - 10) = 1.29794 - 0.10807X$$

The decrease in turnover as indicated by this secular trend, on an average, was approximately one-half of one per cent.

Variations from trend indicated a small turnover in depression periods and a large turnover in war periods, particularly in World War II. When economic conditions were removed from the variations from trend, no apparent reasons could be advanced for the resulting variations. If such factors as school legislation, school consolidation, and inaugurations of other educational programs are related to turnover, their effects must be gradual rather than immediate.

Whenever turnover occurs, the replacement may be (1) someone who has never held an Iowa school superintendency, (2) someone who has previously held an Iowa superintendency but who has not served in that capacity immediately before he became a replacement, and (3) someone who has moved directly from another Iowa superintendency. These replacements, for convenience, have been designated as first entrant replacement, re-entrant replacement, and migrant replacement, respectively.

The absolute number of first entrants needed for replacement has been rapidly decreasing during the 45 years studied.

It appears from the secular trend that approximately 50 superintendents who are first entrants will be needed annually during the next 10 years for approximately 850 Iowa school districts maintaining high schools.

The part that first entrant replacement plays in turnover has averaged 46 per cent during the 45-year period. The annual decrease has averaged approximately two-thirds of one per cent annually.

Re-entrant replacement has occurred, on an average, 6 per cent annually. No particular long-time change was noted, but greater replacement of this type was noted during war periods. There has been some relationship noted to periods of prosperity and depression with the smaller re-entrant replacement having been found in the latter.

Migrant replacement, on an average, has annually occurred in 11 per cent of the Iowa school districts maintaining high schools. An analysis of the secular trend revealed, for all practical purposes, neither an upward nor downward secular trend during the period studied.

When turnover has occurred, succeeding years, on an average, show percentage of such annual turnover resulting in migrant replacement. The increase, on an average, has been more than one-half of one per cent annually. During the past 10 years more than one-half of all Iowa turnover has resulted in migrant replacement.

Although it was beyond the purpose of this study to ascertain the desirable minimum migrant replacement, the amount of such replacement shown in the Iowa schools has far exceeded a desirable minimum. Furthermore an analysis of the secular trend revealed little or no evidence of improvement in the immediate future.

Of all the problems here studied dealing with turnover and the various types of replacement, the problem of migrant replacement appears most acute and constitutes a direct challenge for public education in Iowa.

RESPONSES OF BARLEY AND OATS TO 2,4-DICHLOROPHENOXYACETIC ACID¹

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Selective herbicides have been used for weed control since the turn of the century, but the use of 2,4-dichlorophenoxyacetic acid (2,4-D) has been developed during the past decade. This chemical is a valuable adjunct to weed control because numerous broad-leaved weeds are susceptible to low rates of application and many agronomic crops are tolerant to these small dosages. Since some crops may be injured, it was desirable to obtain more information regarding the reaction of barley and oats to treatments with the chemical.

One purpose of this study was to determine the differential responses in yield, components of yield, seed viability and morphological characters of several economically important barley and oat varieties when treated with three 2,4-D formulations at four stages of growth. A second purpose was to correlate yield response with physiological activity and morphological stage of development at time of treatment. A third purpose was to determine whether yield reductions and morphological abnormalities were transmitted to the succeeding generation through the seed.

To study varietal response, Spartan, Plains, Feebar, Kindred, Odessa, Manchuria and Wisconsin 38 barley varieties, and Brunner, Trojan, Richland, Vikota, Tama, Mindo, Clinton, Marion and Bonda oat varieties were tested in 1947, 1948 and 1949. In addition, Tregal barley was tested in 1947, and Moore barley and Andrew oats were treated in 1949. Butyl ester, triethanol amine and monohydrate sodium salt forms of 2,4-D were applied at the rate of one pound acid equivalent per acre at the 5-leaf, fully tillered, heading and milk stages of growth. Data on yield

and seed viability were obtained each year. Seed-weight of barley was determined the last two years, while number of spikes was determined and number of seeds per spike was calculated the third year.

The yields of barley and oat varieties were consistently reduced by treatment with the ester at the first three stages of growth. In barley the reduction was greatest on plots treated at first (5-leaf) and third (heading) stages, but there was a slight decrease at the second (fully tillered) stage. In oats the yields were reduced 15 to 20 per cent at the 5-leaf stage and 5 to 10 per cent at the fully tillered and heading stages. The 2,4-D salts also reduced barley yields slightly at the critical 5-leaf and heading stages but did not consistently affect yields of oats. In 1949 each decrease in yield of barley was accompanied by a similar reduction in the number of seeds per spike.

Varieties of barley and oats did not respond in a different way to treatment at different stages of growth. There was some indication that Wisconsin 38 was more susceptible to the ester form than other barley varieties tested, while Clinton, Marion and Mindo oats were more susceptible than Andrew and Bonda, which in turn were more susceptible than the other oat varieties tested.

Grain from abnormal spikes of 2,4-D treated barley plants was seeded in head-rows to observe the effects on their progeny in two succeeding generations. Seed from untreated plants and from plants on which yield had been reduced was planted also, to determine if the low yield was transmitted to the next generation through the seed. Barley varieties grown in 1948 were tested for yield in 1949 and the barley and oat varieties grown in 1949 were tested in 1950. It was not established that either reduced yield or morphological malformations were transmitted to the next generation through the seed.

In a study of physiological responses, an early and a late variety of barley were treated with one pound acid equivalent

1 a. Chairman of Committee, I. J. Johnson, Professor, Dept. of Agronomy, Agricultural Experiment Station and W. E. Loomis, Professor, Dept. of Botany, Agricultural Experiment Station.
b. Doctoral Thesis No. 1154. Submitted March 13, 1951.

2 a. B. S., South Dakota State College, Brookings, S. Dakota, 1943.
M. S., *ibid.*, 1948.

b. Cooperator Agricultural Experiment Station.

of butyl ester of 2,4-D at nine stages of growth. Plains was used as the early variety each year; and Wisconsin 38 was used as the late variety in 1949, but Moore was substituted for it in 1950. The 2,4-D was applied at three-day intervals beginning at the 4- to 5-leaf stage, and growing points were dissected to determine the exact stage of growth treated. Dissections were made from the central culm in 1949 and from the central culm and all tillers in 1950. Yield, seed-weight and number of spikes were determined and number of seeds per spike was calculated each year.

The results indicated that the growth of barley can be divided into four developmental periods, each responding in a different way to 2,4-D. The four developmental periods are: (1) a susceptible seedling period which ends at the 5-leaf stage, (2) a relatively tolerant period between the 5-leaf and the early boot stage, (3) a second susceptible period from preheading to late heading and (4) a resistant post-heading period.

During the latter part of the seedling period the differentiation of tiller buds was inhibited by the application of 2,4-D. When the number of tillers was reduced, the number of spikes was decreased and yield was greatly depressed. In the second period floral initiation was inhibited, the number of seeds per spike was depressed and yield was reduced. The severity of the injury was associated with the number of growing plants in the process of differentiation at the time of treatment. In a dry year when floral initiation was rapid, 2,4-D applications caused significant reductions in yield at the time of differentiation, but did not materially affect yield when applied after floral differentiation in the central culm and before the differentiation in the tillers. In a wet year when floral initiation was slower, treatments caused small decreases in yield over a two-week period. In the heading period it is not certain what physiological process was affected, but

it may have been an inhibition of embryo sac and/or gamete development and it may have been an increased vegetative competition for food as a result of stunting the central culm. Yield reductions were due to a decreased number of seeds. During the post-heading period, there was no differentiation of meristematic tissue and the application of high rates of 2,4-D did not reduce yields.

Germination of seed showed that viability of nine barley and ten oat varieties was not impaired by the application of any of the 2,4-D formulations at the 5-leaf, fully tillered, heading and milk stages of growth, and that the viability of two varieties of barley was not impaired at nine developmental stages.

The frequency of morphological malformations was increased by the application of 2,4-D. Treatments that gave the greatest reduction in yield also gave the most abnormalities. In barley, the florets were disarranged during the two earlier periods, while the blasting of florets and some lodging were caused during the heading period. An onion-leaf malformation in oats developed after the application of the ester at the 5-leaf stage.

From the results of this investigation, it may be concluded that applications of 2,4-D for weed control in barley and oats should be made between the 5-leaf and early boot stages of growth or after the milk stage in order to cause a minimum amount of injury to the crop. Yield reductions can be expected during the early period from heavy rates of 2,4-D, especially the ester form, unless treatment is made during the very short (less than six days) period after the youngest tillers start to elongate (elongation follows floral initiation) and before the sheaths of the oldest culms start to swell. Wisconsin 38 barley and Andrew and Bonda oats are slightly susceptible to 2,4-D. Mindo, Clinton and Marion oats are highly susceptible and should not be sprayed unless the weed competition might cause a large reduction in yield.

RELATIONSHIPS BETWEEN SOME ORGANOSILICON COMPOUNDS AND THEIR CARBON ANALOGS¹

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Early investigators who worked with organosilicon compounds felt hopeful that their experiments would lead to a whole new chemistry of silicon analogous to that of carbon. Later work has shown this hope to be unfounded, due largely to three factors; the reactivity of the silicon-hydrogen bond, the difficulty of building up chains of silicon atoms, and the difficulty of preparing unsaturated linkages to silicon. In this study the properties of a number of triarylsilicon compounds were compared with those of their carbon analogs in order to obtain some further insight into the nature of the differences between organic and organosilicon chemistries.

It is known that triphenylcarbinol is metalated by *n*-butyllithium. When triphenylsilanol was treated with *n*-butyllithium, the products of the reaction were diphenyl-*n*-butylsilanol and phenyllithium, showing that fission of a silicon-carbon bond had occurred instead of metalation. This was found to be a fairly general reaction of triarylsilanols, except for the case of tri-1-naphthylsilanol, where the reaction is retarded, probably by steric hindrance. A number of tetraalkyl- and mixed alkylaryl-silanes did not react with *n*-butyllithium, leading to the conclusion that the oxygen atom of the silanols must facilitate the cleavage in some way, perhaps by affording a nucleophilic center for coordination with the lithium of *n*-butyllithium.

A well-known difference between organosilicon compounds and analogous carbon compounds is seen in the ease with which hexaarylethanes dissociate into radicals, compared with the extreme stability of the hexaaryldisilanes. This could be due to reduced steric strains in the silicon compound because of the larger

size of the silicon atoms, but it has also been reported that triarylhalosilanes containing bulky groups do not react with alkali metals. In order to investigate the possibility that the difference in the carbon and silicon series may be due to reduced resonance stabilization of the silicon radicals, hexa-*p*-xenylsilane was prepared. The carbon analog of this compound is reported to be completely dissociated, even in the solid state. The silicon compound showed no reactivity toward oxygen or iodine, and melted undecomposed at the high temperature of 430°. Evidently its tendency to dissociate is very small, and this is attributed to small resonance contributions from structures containing silicon-carbon double bonds.

The question of resonance stabilization was further investigated by comparing the ultraviolet absorption spectra of some triphenylmethane dyes and their carbon analogs in neutral and acid solution. Whereas the carbon compounds showed a strong shift of absorption maxima toward longer wave lengths when converted to carbonium ions by acid, the silicon compounds showed no such shift. Evidently the silanols are not converted to carbonium ions by acids as readily as are the carbinols. This, too, is probably due, at least in part, to small resonance contributions to the ground state of siliconium ions by structures containing silicon-carbon double bonds.

Another approach to the question of the importance of resonance contributions from structures containing silicon-carbon double bonds was made by comparing the rates of hydrolysis of a number of substituted triarylsilanes in wet piperidine with the *sigma* constants for the substituents. *Rho* for this reaction was found to be large and positive (+3.09). For a series of seven substituents the agreement between rate constant and *sigma* was good, with the exception of the *p*-dimethylamino group. This difference was attributed to the importance in carbon compounds (substituted benzoic acids, for example) of resonance contributions from *p*-quinoid structures in which the carbon atom of

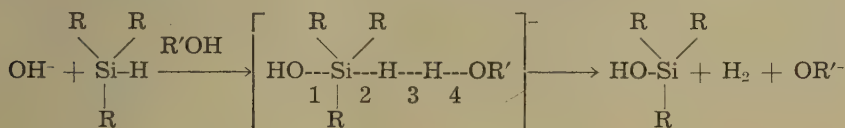
- 1 a. Chairman of Committee, Henry Gilman, Professor, Dept. of Chemistry, Industrial Science Research Institute.
- b. Doctoral Thesis No. 1155. Submitted March 13, 1951.
- 2 a. B. Sc. Acadia University, Wolfville, Nova Scotia, 1943.
- M. A., University of Toronto, Toronto, Ontario, 1946.
- b. Fellow Industrial Science Research Institute.

the side chain is doubly bonded to the benzene ring. The contributions of similar structures in silicon compounds are evidently much smaller, probably because they would require silicon-carbon double bonds.

The mechanism of the hydrolysis of triarylsilanes by wet piperidine was studied kinetically, following the course of the reaction by measuring the hydrogen evolved. The reaction was found to be first order in silane, and half order in water. When run in methylcellosolve it was found to be first order in silane, half order in piperidine, and zero to half order in water. The half order in piperidine and water was taken to indicate that the attacking species is hydroxyl ion, which displaces a hydride ion, and that the reaction is first order in hydroxyl ion. Evidently the incipient hydride ion immediately accepts a proton from the solvent to form hydrogen gas

breaking the silicon-hydrogen bond is part of the rate controlling step. Since most protium compounds react faster than their deuterium analogs, the large abnormal isotope effect observed here was of particular interest. It indicates that the zero-point energy of the transition state is greater than that of the ground state for the system, probably due to the partial formation of a hydrogen-hydrogen bond in the transition state. This indicates that formation of bond 3 in the above equation is almost complete in the transition state, and the positive ρ for the reaction indicates that bond 1 is more nearly formed than bond 2 is broken.

Finally, the reaction of triphenylsilane with alcohols in the presence of piperidine was applied to the synthesis of a number of triphenylalkoxy silanes. The yields and melting points of the following compounds obtained by this procedure, were reported: triphenylethoxysilane (40%), m.p. 65-66°;



In order to find out if the breaking of the silicon-hydrogen bond is involved in the rate determining step, the rates of hydrolysis of triphenylsilane and triphenyldeuterosilane were compared. Triphenyldeuterosilane reacts about six times faster than triphenylsilane, indicating that

triphenyl - (2-methoxyethoxy) - silane (78%), m.p. 67-68°; triphenyl-*sec.*-butoxysilane (38%), m.p. 120-122°; hexaphenyl-disiloxane (45%), m.p. 220-221°; 1,1,1-triphenyl-1-2,2,2-tri-*p*-tolylidisilane (35%), m.p. 160-162°.

STATISTICAL ANALYSIS OF LONG-TERM AGRICULTURAL EXPERIMENTS¹

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Data from long-term agricultural experiments consist in general of the yield histories of several plots subjected to possibly different long-term cropping systems. The classical method by which such data are analyzed is that of fitting linear functions of orthogonal time polynomials to the yields from each plot by the principle of least squares. Different cropping systems are compared by means of the estimates of the coefficients of correspondingly ordered polynomials in each series. The noteworthy assumptions made with this method of analysis are (1) that the underlying yield trend can be expressed by a low ordered time polynomial and (2) that the yearly deviations from such a trend are independent.

The classical model has been criticized on several scores. Yield trends do not seem to exhibit the polynomial type of regression. The coefficients of polynomials, except for the coefficient of the linear term, have very little biological meaning.

More serious criticisms have been leveled at the independent error model. There is evidence of a negative serial correlation between the consecutive yields from long-term experiments. Additional evidence is presented in this dissertation in the form of standardized serial correlation coefficients calculated from the deviations from least squares regression lines for a large number of well-known experimental plots. Of the 14 serial correlation coefficients so calculated, 10 are negative. Of the negative coefficients 6 are beyond the 20 per cent significance level under the hypothesis of zero population serial correlation.

A logical bio-mathematical yield model which consists of a simple autocorrelated error superposed on an exponential trend is given in the dissertation. This model is not subject to the criticisms of the clas-

sical model. The theoretical portion of the dissertation is concerned with obtaining maximum likelihood estimators for the parameters involved in this model and establishing confidence interval rules for them where possible. A programme of increasingly complex models, from the case of a single series with a linear regression on an independent variate and a simply autocorrelated error to the case of k correlated series with the exponential regression and an autocorrelated error model, are considered.

The linear regression model is considered only for the purpose of obtaining preliminary equations which may be readily generalized to the exponential regression model. Despite this fact the linear model itself may be applicable to some yield series or restricted portions of them.

The simplest model considered is of the form $y_i = a + bt_i + \eta_i$ where $\eta_i = a\eta_{i-1} + \varepsilon_i$ and $|a| < 1$. In this model the y_i are the observed yields in the i th year and the t_i are the independent observed constants. The ε_i are assumed to be random yearly stochastic variables with zero means and variance σ^2 . Under the assumption of normality of the ε 's, an iterative method of obtaining the maximum likelihood estimates is given. A confidence interval rule is presented for the parameters a and b .

The simple regression model is extended to the case of two series in which the corresponding yearly ε 's are correlated. The model is finally extended to the case of k such correlated series with different correlations between the ε 's of different pairs of series. The most general linear regression model considered is of the form

$$y_{ij} = a_i + b_i t_{ij} + \eta_{ij}, \text{ where} \\ \eta_{ij} = a_i \eta_{i, j-1} + \varepsilon_{ij}, |a_i| < 1 \text{ for } i = 1, \\ \dots, k, j = 1, \dots, n.$$

y_{ij} is the yield in the j th year on the i th series. t_{ij} is the corresponding independent variate. The ε_{ij} are assumed to be normally distributed with zero means and such that $\text{var } \varepsilon_{ij} = \sigma^2$, $\text{cov } \varepsilon_{ij} \varepsilon_{i'j} = \rho_{ii'} \sigma^2$, and $\text{cov } \varepsilon_{ij} \varepsilon_{i'j'} = \text{cov } \varepsilon_{ij} \varepsilon_{i'j'} = 0$, for $i \neq i'$ and $j \neq j'$. A well-known trans-

- 1 a. Chairman of Committee, Oscar Kempthorne, Associate Professor, Dept. of Statistics, Agricultural Experiment Station, Statistical Laboratory.
- b. Doctoral Thesis No. 1181. Submitted June 8, 1951.
- 2 a. B. S., Iowa State College, Ames, Iowa, 1945.
- b. Instructor Dept. of Statistics and Associate Statistical Laboratory.

formation to independent variates is made in order to find the probability density distribution of the observed yields. A procedure for iterative solution of the maximum likelihood equations for a_i , b_i , σ^2 , and approximate confidence interval rules for the parameters a_i and b_i for $i = 1, \dots, k$, are established.

The model for a single series is extended to include exponential regression of the yields on time with an autocorrelated error. The model is

$$y_i = a + b(r)^{i-1} + \eta_i$$

where the η_i are defined as in the case of linear regression. An iterative procedure for estimating the parameters a , b , r , σ^2 is established. A rule for obtaining approximate confidence intervals for a and b at any desired probability level is set forth.

The exponential model is extended to the case of two series and, finally, to the case of k correlated series. The model for

k such series is $y_{ij} = a_i + b_i(r_i)^{j-1} + \eta_{ij}$

where the η_{ij} are defined as in the linear regression model for k series. Extensions are presented for the equations obtained

in the linear case to cover exponential regression. The maximum likelihood equations for the new parameters r_i , $i = 1, \dots, k$, are presented. The iterative methods of solution for the linear case as well as the approximate confidence interval rules are extended to include exponential regression on time.

For the general case of k correlated series with either a linear regression model or an exponential model the procedures for simultaneous solution of the estimation equations are too complicated for practical application. In the case of two correlated series with either model, however, the procedures, although tedious and long, are not impossible to apply. The methods of solution for these cases are illustrated in the dissertation by applying them to some actual yield series from the experimental plots of Sanborn Field at the University of Missouri.

The procedures set forth in this work are not seriously advocated for the case of more than two correlated yield series when all the parameters involved are unknown. They do, however, provide a formal solution to an otherwise intractable problem. Useful approximations will necessarily be based on these rigorous procedures.

SIGNIFICANCE OF SOIL ORGANIC PHOSPHORUS TO PLANT GROWTH¹

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The organic phosphorus may represent as much as one-half or more of the total phosphorus in the surface horizon of prairie soils. Laboratory experiments have shown that the mineralization of organic phosphorus is correlated with the mineralization of nitrogen and carbon in the soil organic matter. Since the nitrogen mineralized from the soil organic matter may be the sole source of nitrogen available to the growing crop it appears likely that organic phosphorus is of importance in plant nutrition in prairie soils. Experi-

ments on the response of various crops to phosphate fertilization in Iowa have shown that the crops that make most of their growth in the spring when the soil is cool show greater deficiencies of phosphorus than do crops making most of their growth later in the season when the soil is warmer. The same is true of nitrogen, where the non-leguminous crops are concerned. This evidence, together with the results of laboratory experiments showing an increase in organic phosphorus mineralization with temperature, indicates that under field conditions crop response to phosphate fertilization should decrease as the soil temperature increases as a result of the greater availability of phosphorus from the organic form. In a group of soils, therefore, the decrease should be related to the amount of organic

- 1 a. Chairman of Committee, C. A. Black, Professor, Dept. of Agronomy, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1084. Submitted July 13, 1950.
- 2 a. B. S., Fouad I University, Cairo, Egypt, 1940.
M. S. Iowa State College, Ames, Iowa, 1947

phosphorus being mineralized in different soils.

In the present investigation the hypothesis that soil organic phosphorus is of importance to crops during the current season was tested by different experiments. In the first experiment, oats, soybeans and corn were grown in the greenhouse with soil temperatures of 20 and 35°C. and with three rates of monocalcium phosphate addition on two soils with three replications in a split-plot design. The one soil, Fayette silt loam C horizon, was high in soluble inorganic phosphorus but contained practically no organic phosphorus. The other soil, virgin Fayette silt loam A horizon, was high in both organic phosphorus and soluble inorganic phosphorus. The soils were mixed with sand and all pots were supplied with nutrients other than phosphorus. When the yields were calculated on a relative basis, the yield with the highest phosphate treatment being given a value of 100 in each case, it was found that the degree of phosphorus deficiency indicated in the soils receiving no phosphate was greatest with oats, intermediate with corn and least with soybeans. With the Fayette C horizon low in organic phosphorus there was no significant change in the degree of phosphorus deficiency within crops between temperatures. With the Fayette A horizon high in organic phosphorus the degree of phosphorus deficiency indicated by corn and soybeans was less at the high soil temperature than at the low soil temperature. Oats showed the reverse. Thus, the results with corn and soybeans were in agreement with the hypothesis and the results with oats were not. On the absolute basis, corn and soybeans made somewhat better growth at the high soil temperature than at the low soil temperature, but oats made good growth at the low temperature and poor growth at the high temperature.

In the second experiment corn was grown on 17 different acid soils and on quartz sand, and in the third experiment corn was grown on 18 different calcareous soils. In both experiments there were three rates of monocalcium phosphate addition, soil temperatures of 20 and 35°C., and three replications of all treatments in a split-plot design. The soils were mixed with sand and all pots were supplied with nutrients other than phosphorus.

On the assumption that the Mitscherlich equation could be used to represent the behavior of the corn toward phosphate, the average value for the proportionality constant c was calculated from the corn

yield data on all soils and used subsequently in a least squares method for finding the other constants in the equation for each soil. In this manner the plant-available phosphorus b in the soil without added phosphate was calculated in terms of the effect produced by monocalcium phosphate.

Since there were no laboratory methods for estimating the availability of soil organic phosphorus to plants, various methods were used on the samples of soil from the above experiments to see whether one or more methods would show a correlation with the calculated values of plant-available phosphorus in the soil. To permit the separation of the effects of organic and inorganic phosphorus availability by the methods of multiple regression and partial correlation, the soil samples were analyzed also for soluble inorganic phosphorus.

In the experiment with acid soils partial correlations of the soluble inorganic phosphorus with the plant-available phosphorus independent of the organic phosphorus fractions were significant at both soil temperatures. In the experiment with calcareous soils partial correlations of the soluble inorganic phosphorus with the plant-available phosphorus independent of the organic phosphorus fractions were significant at the low soil temperature but not at the high soil temperature. In both experiments the partial correlations of the various organic phosphorus fractions with the plant-available phosphorus independent of the soluble inorganic phosphorus were not significant at the low soil temperature but were significant with certain fractions at the high soil temperature. The results of these experiments are in agreement with the hypotheses that soil organic phosphorus contributes during the growing season to the phosphorus nutrition of the crop and that the contribution is greater at high soil temperatures than at low soil temperatures.

Simple correlations of the inorganic with the organic phosphorus fractions were practically always positive and in a number of cases were significant. Thus, if only one fraction were measured and correlated with plant-available phosphorus a part of the contribution of the other unmeasured fraction would be included in the correlation.

Of the laboratory methods investigated, the amount of organic phosphorus dephosphorylated by hypobromite in a soil extract made with hot 1 per cent potassium carbonate appeared to give the best esti-

mate of organic phosphorus availability. The fraction not dephosphorylated by hypobromite showed no important correlation. The partial correlation involving the total organic phosphorus in the potassium carbonate extract with the plant-available phosphorus independent of the inorganic phosphorus was lower than the corresponding correlation for the hypobromite-dephosphorylated organic phosphorus in the calcareous soils and slightly higher in the acid soils. The total organic phosphorus showed a significant partial correlation in the calcareous soils but not in the acid soils. Permanganate dephosphorylation was not as effective as was hypobromite dephosphorylation in distinguishing between the organic phosphorus correlated and that not correlated

with plant-available phosphorus in the calcareous soils. The permanganate treatment was not used on the acid soils.

The laboratory methods used for estimating soil organic phosphorus availability were empirical. They could undoubtedly be improved by further experimentation. However, the experimental work reported in this investigation represents the first step toward improving soil phosphorus availability tests by including measurements of soil organic phosphorus. The results indicate that for soils high in organic phosphorus an estimate of organic phosphorus availability may bring about a substantial improvement in the accuracy with which the need for phosphate fertilization can be predicted.

GENETIC FACTORS GOVERNING RESISTANCE AND SUSCEPTIBILITY OF OATS TO *PUCCINIA CORONATA*

AVENAE ERIKS. & E. HENN., RACE 57¹

VERNE CLIFFORD FINKNER²

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Maintaining resistance to crown rust of oats, *Puccinia coronata* Corda., f. sp. *avenae* (Eriks. & E. Henn.) Eriks., has been a major problem in oat breeding programs. The mechanism of reproduction of the pathogen gives opportunity for variation in pathogenicity. Selection pressure produced by host varieties eliminates those physiologic races of the pathogen to which the varieties are resistant but at the same time provides an opportunity for the increase in prevalence of those races to which they are susceptible. It is improbable that any one combination of genes for resistance to crown rust will provide resistance to all present and future races of the pathogen. However, it is probable that some combination of genes for resistance can be found that will give resistance

to any one or more prevalent races of crown rust. Breeding for resistance to crown rust therefore may be a continuous problem and the maintenance of resistant varieties will depend upon the location and transfer of genes for crown rust resistance to agronomically desirable varieties.

The most efficient method to attain this objective would be to catalogue sources of resistance to specific races and to determine the genetic factors carried by those sources as measured by host-parasite relationships.

This investigation was conducted to determine genetic factors governing resistance and susceptibility to race 57. Eight major crown rust resistant sources, seven of which were resistant to crown rust race 57, were catalogued for genes conditioning resistance and susceptibility. Twenty-three of the possible twenty-eight crosses among those eight varieties were classified in the F₂ generation for crown rust reaction. The F₂ classification was confirmed or corrected by a progeny test. A factorial interpretation of the data was as follows:

- 1 a. Chairman of Committee, I. J. Johnson, Professor, Dept. of Agronomy, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1098. Submitted August 11, 1950.
- 2 a. B. S., Colorado State College, Fort Collins, Colorado, 1947.
- b. M. S., Kansas State College, Manhattan, Kansas, 1948.
- b. Associate Agricultural Experiment Station.

Variety	C.I. No.	Phenotype	Proposed genotype					
1. Klein 69b	4118	Resistant	KK	mm	uu	vv	ll	i _k i _k
2. Trispermia	4009	Resistant	kk	M ₂ M ₂	---	---	ll	i _k i _k
3. Victoria	2401	Resistant	kk	mm	uu	VV	ll	i _k i _k
4. Santa Fe	4518	Resistant	kk	M ₁ M ₁	uu	vv	ll	i _k i _k
5. Ukraine	3259	Resistant	kk	MM	UU	vv	ll	i _k i _k
6. Landhafer	3522	Resistant	kk	mm	uu	vv	LL	i _k i _k
7. Reselect Clinton	5011	Susceptible	kk	mm	uu	vv	ll	i _k i _k
8. Anthony-Bond x Boone	5220	Resistant	kk	M ₂ M ₂	---	V ₁ V ₁	ll	I _k I _k

The interallelic and intrallelic gene action was as follows:

1. M, U, or MU conditioned an immune type reaction and were epistatic or dominant to all others.
2. M₁ and L conditioned a zero type reaction and were epistatic or dominant to all others except M, U, and MU.
3. V conditioned the Victoria type of crown rust reaction and was dominant to V₁ (two type) and epistatic to K (two type).
4. I_kI_k conditioned a susceptible reaction and was epistatic to K.
5. The genes designated as M and U were linked with $22.88 \pm .04$ per cent crossing over. All other genes showed independence.

In conjunction with the crown rust investigation data were recorded for the inheritance of reaction to *Helminthosporium victoriae*, Meehan and Murphy, inheritance of dwarf plants, first leaf sheath pubescence, first leaf marginal hairs, occurrence of albino plants, and inheritance

of resistance and susceptibility to a race of crown rust which would attack the oat variety Ukraine.

Susceptibility to *H. victoriae* was found to be dominant and completely linked with the gene designated as V governing resistance to crown rust race 57.

A hypothesis of two partially dominant complementary factor pairs was advanced to explain the occurrence of dwarf plants in the F₂ generation from normal parents and normal F₁'s.

A factorial interpretation of inheritance of first leaf sheath pubescence and of first leaf marginal hairs was not advanced. The F₂ data indicated recovery of parental types and other types within the range of the parents.

Albino seedlings were obtained in fifteen F₃ lines from eight of twenty-four crosses. Albino seedlings were not obtained in the F₂ generation.

Susceptibility to a race of crown rust which parasitized Ukraine may be associated with one of the two dominant linked factors governing the Ukraine type of resistance to race 57.

CHLOROSIS OF AZALEAS¹

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Most of the soils and the water used as a source of soil moisture in commercial greenhouses in Iowa contain relatively high amounts of calcium and magnesium

salts. The presence of these basic salts in the soil solution will generally produce conditions which promote iron chlorosis and are deleterious to the best growth of ericaceous plants. The current investigation was initiated for the purpose of studying the effects of fertilizers, potting media, and soil reaction upon the quantities of ferrous and ferric iron in the soil and leaves of azaleas; and the relationship of these two forms of iron to the foliage color, number of flower buds and plant quality scores of the plants when watered with hard (tap) water and soft

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water. In general, the plant responses and soil analyses followed more definite patterns when the plants were watered with soft water in which the basic salts were not present to initiate secondary, and possibly overlapping reactions, in the soil.

The Kurume type azalea, variety Coral Bells, was used in all studies reported in this paper. All plants, except those used in Experiment A, 1948, were rooted cuttings at the initiation of the experiments. Recommended cultural practices regarding watering, syringing, shading, pinching and control of greenhouse temperatures were followed. The potting medium used in all experiments, except Experiment B, 1948, was either an alkaline sedge peat soil or acid sphagnum peat soil. In Experiment B, 1948, Lindley soil (a fine-textured acid soil, low in available nutrients) failed to provide a suitable growing medium for azaleas.

All experiments were arranged in randomized blocks designs. Data collected included pH of the medium, number of flower buds, foliage color, plant quality and ferrous and ferric iron in leaves and soils. The pH determinations were made with a Coleman glass electrode pH meter. The record of flower buds was a count of the number developed on each plant. Foliage color scores were assigned after a visual inspection of each plant, and ranged from 1 to 4 in the preliminary studies and 1 to 10 in the final experiments. Plant quality was a sum of the growth responses of the plant, such as, vigor, compactness of growth, foliage color and number of flower buds.

Colorimetric determinations of extractable ferrous and ferric iron from leaves were made with a Coleman spectrophotometer according to the procedure outlined by Thorne and Wallace (1944). Orthophenanthroline was used as the indicator of ferrous iron in leaf extracts.

The extraction and determination of iron in mineral soils were made using 2,2'-bipyridyl as an indicator (Ignatieff, 1941). The above procedure was modified in several ways to adapt its use to peat soils, and to determine extractable ferric iron.

Soil acidity was found to contribute

markedly to the absorption and utilization of iron by azaleas. The pH of the soil was found to be negatively correlated with flower bud production, foliage color, plant quality, and ferrous iron extracted from the soil when the plants were watered with hard water, and flower buds, plant quality and ferrous iron in the soil when the plants were watered with soft water. Plant quality scores were generally higher when the pH of the medium ranged from 4.0 to 5.0. pH's below 4.0 appeared to be injurious.

The presence of moderate quantities of ferrous iron in the potting medium was associated with the best growth and flowering. Ferrous iron in the soil was found to be positively correlated with foliage color and plant quality when the plants were watered with soft water.

Phosphorus tended to interfere with the absorption and utilization of iron, as verified by the smaller mean foliage color and plant quality scores of those treatments to which it was applied.

Application of iron (ferrous, inorganic) and aluminum salts to the medium, especially when the plants were watered with hard water, consistently improved the mean foliage color and plant quality scores.

The use of anti-oxidant compounds as soil conditioners did not prove to be a practical value for correcting iron deficiency chlorosis of azaleas.

Nitrogen, when applied to acid peat alone or in combination with organic iron greatly improved the commercial value, including leaf color, of azaleas. The outstanding treatment of this study consisted of an application of dried blood (which contains reasonably large amounts of organic iron and nitrogen) to acid peat.

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MECHANISM OF AMMONIATION IN *AEROBACTER AEROGENES*¹

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Euler, *et al.* (1937) and Adler, *et al.*, (1938) were able to demonstrate an ammoniation of α -ketoglutarate. Virtanen and Laine (1938) have suggested the ammoniation of oxalacetate, and hence the synthesis of aspartate as a means for ammonium ion assimilation. Excepting work in the related field of nitrogen fixation, ammoniation has received little further attention. This investigation was undertaken to determine the possible pathways of assimilation of ammonium ion and to study some of the characteristics of the bacterial enzyme systems concerned.

It was shown that reproducing cells using glucose as a substrate formed large amounts of glutamate in the medium when conditions were aerobic; sodium fluoride and methadon hydrochloride inhibited and sodium arsenite stimulated the synthesis of glutamate. The results were related to specific action of the respective inhibitors. Glutamate did not accumulate in as high a concentration under anaerobic conditions as under aerobic conditions, a result to be expected since the precursor of glutamate, α -ketoglutarate, accumulates in an oxidative system. Alanine is formed in higher concentration in an anaerobic system. Sodium fluoride inhibited the formation of alanine, glutamate and aspartate when glucose was the substrate. The amount of growth decreased both aerobically and anaerobically when the α -keto acids, pyruvate and α -ketoglutarate, were substituted for glucose as a substrate. However, more growth was observed in the absence of oxygen than in its presence when pyruvate was used as a carbon source. Pyruvate was shown to be a better substrate for growth, as determined by turbidimetric readings, than was α -ketoglutarate. The use of pyruvate as a substrate resulted in formation of aspartate in con-

centration three to five times that of the control which contained both pyruvate and α -ketoglutarate. Excess glutamate was not formed from α -ketoglutarate by growing cells. The formation of excess aspartate and the stimulation of growth by pyruvate in the presence of CO₂ substantiated the findings of Ajl and Werkman (1949) that growth was prevented in the absence of carbon dioxide.

Washed cells and dialyzed cell-free juices of *A. aerogenes* were shown to require only α -ketoglutarate and ammonium ion for ammoniation and synthesis of glutamate. On the other hand, synthesis of aspartate by such a system required Mg⁺⁺, adenosine triphosphate, ammonium chloride, cysteine and pyruvate. α -Ketoglutarate, sodium bicarbonate and glycerolphosphate were also required but to a less degree. The synthesis of alanine under these conditions was depressed by the presence of sodium bicarbonate. The importance of pyruvate, phosphorylation and carbon dioxide fixation were shown by the results.

It was shown that the amide nitrogen of glutamine did not act as the source of -NH₂ for the synthesis of aspartate. The presence of cysteine was shown to stimulate the synthesis of aspartate probably through its action in a hydrogen transport system.

Aspartate was forced in higher concentration than glutamate in experiments of ten-minute duration; however, more glutamate than aspartate was synthesized when a ninety-minute reaction time was employed. The results indicated a rapid initial ammoniation of a precursor of aspartate, i.e., some form of oxalacetate.

Results obtained by using N¹⁵H₄Cl support the suggestion of ammoniation of oxalacetate. More N¹⁵ was found in aspartate after a ten-minute reaction than was found in the respective glutamate fraction. The observed difference disappeared as the reaction time was increased to ninety minutes.

The importance of carbon dioxide was shown by the use of NaHC¹⁴O₃. Labeled C¹⁴ was found in aspartate and an unidentified amino acid thus indicating the importance of the fixation of carbon dioxide

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in the synthesis of aspartate from pyruvate. Pyruvate labeled with C^{14} in the carbonyl group was also used as a substrate. The C^{14} was found in alanine and in glutamate. The high concentration of C^{14} per mole of glutamate was interpreted to indicate a condensation of at least two residues containing C^{14} .

The results have been presented as strong evidence for the ammoniation of some form of oxalacetate to yield aspartate. The ammoniation of α -ketoglutarate also takes place probably by the mechanism of Euler, *et al.* (1937). Evidence for the reductive ammoniation of pyruvate was not obtained.

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SOME OBSTACLES TO RECOMMENDED LAND USE PRACTICES IN WESTERN IOWA AND MEANS FOR OVERCOMING THEM ¹

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Efforts by public land use programs in Iowa to check depletion and deterioration of the soil resources have been compromised by basic obstacles and resistances within the agricultural environment. The purpose of this investigation was (1) to delineate in a seriously eroded land area of the state the divergence between present soil erosion losses and the erosion control objectives of land use programs, (2) to determine some of the economic and related factors which constitute obstacles and resistances to the adoption of erosion control practices, and (3) to suggest hypothetical constructs of action for overcoming the obstacles and resistances to soil erosion control practices.

The Ida-Monona Soil Association Area of western Iowa was selected as the area of study because of its severe soil erosion problems. Forty-eight sections of land were randomly selected from this area, and 144 farms with a headquarters located

within the boundaries of these 48 sections of land were studied.

The gap between the land use program objectives and the present soil erosion losses on the farms in the Ida-Monona Soil Association Area was delineated by three methods: (1) by comparing the estimated needs of land use programs in the area with their accomplishments, (2) by comparing the rates of soil erosion on the farms in the sample with a permissible rate of soil erosion recommended by the programs, and (3) by comparing the number of erosion control practices followed on the farms in the sample with the number of practices necessary to attain a permissible rate of soil erosion.

Evidence on the accomplishments of the land use programs in the area was obtained from state summaries of the needs and accomplishments of the Agricultural Conservation Program of the Production and Marketing Administration and the Soil Conservation Districts. The Agricultural Conservation Program of the Production and Marketing Administration primarily encouraged the adoption of green manure cover crops, contouring, grass waterways, and commercial fertilizers. Although in some counties as many as eleven different practices were approved for payment, the farm operators

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were not using a combination of erosion control practices on the same land area to attain permissible rates of soil erosion. The Soil Conservation Districts had established farm plans on approximately 14 per cent of the farms in the area. Combinations of erosion control practices were planned on the farms of cooperating members, but accomplishments lagged behind the planning activities. Also, less than 6 per cent of the estimated needs for the area in terms of recommended land use practices had been satisfied. At the time the study was made, neither program had reached its expressed soil erosion control objectives.

A wide area of non-compliance was also observed when rates of soil erosion were used to measure how far the farms in the area deviated from the erosion control goal of the land use programs. The rates of soil erosion on 89 per cent of the farms exceeded a permissible average annual soil erosion loss of five tons per acre. Furthermore, less erosion control practices were followed on these farms than the programs recommended. On the average the operators were following only one or two recommended practices per farm, while six or more practices were considered necessary to control soil erosion. Both of these comparisons indicated that a large proportion of the farm operators in the Ida-Monona Soil Association Area were not accomplishing as much soil erosion control as the land use programs advocated.

To determine some of the obstacles and resistances to the adoption of recommended erosion control practices in the area, different economic and related factors were proposed as hypothetical obstacles to be tested. To make the tests, alternative erosion control plans were presented to the farm operators in the sample, and they were asked whether or not each hypothetical obstacle prevented them from following the erosion control practices in the plans. Also, tests of significance were used to determine if higher rates of soil erosion were prevalent on the farms when the operators declared that each of the separate factors was an obstacle.

The following major obstacles and resistances received positive tests: (1) a lack of roughage-consuming livestock on 40 per cent of the farms, (2) crop share rental arrangements and a lack of landlord cooperation on 34 per cent of the farms, (3) a large mortgage indebtedness and high operating costs on 30 per cent

of the farms, and (4) a short expectancy of tenure on 19 per cent of the farms.

In addition to the delimitation of the above obstacles, two or more economic or related factors on the same farm were grouped together and then tested to see if obstacle combinations were present on the farms in the area. The three obstacle combinations which occurred most often were: (1) a lack of roughage-consuming livestock and a small number of acres operated per farm; (2) tenure limitations and a lack of roughage-consuming livestock; and (3) tenure limitations, a lack of roughage-consuming livestock, and a small number of acres operated per farm. Thus, on some of the farms a unique combination of obstacles stood in the way of erosion control, rather than a single obstacle.

The following factors did not appear to be major obstacles and resistances when the delimiting hypotheses were tested (1) the future price expectations of the operators, (2) the machinery and power on the farms, (3) the field layouts and roads, (4) the building and storage capacity on the farms, (5) risk and uncertainty, (6) the cooperation of neighboring farmers, (7) custom and inertia, (8) the ability of the operators to shift the losses from soil erosion, and (9) the unavailability of credit. Although these factors did not qualify as major obstacles and resistances, some of them were subordinate restrictive aspects of the four major obstacles discovered. Thus, they cannot be rejected as unimportant, and further tests must be made before they can be delimited in or out of the obstacles to soil erosion control in the area.

Some insight into possible constructs of action for overcoming these obstacles was gained from the resource aspects of the obstacle situations; however, these constructs of action were not tested. The study showed that a careful appraisal of the objectives of the land use programs was necessary to determine if they lead to socially desirable ends. Also, the delineation of public and private areas of responsibility in bringing about soil erosion control appeared essential so that incentive payments can be used effectively to overcome the obstacles and resistances.

Possible means to overcome a lack of roughage-consuming livestock on the farms included methods for reducing the risk and uncertainty of livestock prices and methods for making additional capital available to the farm operators. Changing the kind of livestock raised or the methods

of handling livestock were suggested for further examination along with livestock share leases and forward pricing.

To overcome restrictions associated with the tenure limitations, changes in the traditional crop share leases were advanced to bring about a more equitable distribution of erosion control costs and returns between landlords and tenants. Also, additional research was recommended to determine the reasons why landlords were not willing to have erosion control programs on their farms, and to determine ways and means for bringing landlords and tenants together to work out additional provisions in the rental arrangements.

Possible solutions to the problem of overcoming a pressure for immediate income on the farm included: (1) a long-time program of erosion control to reduce the additional costs during any one year, (2) amortizing farm mortgages over a long period of time, and (3) incentive payments from public agencies to cover part of the costs of the erosion control practices.

Farm operators with a short expectancy of tenure needed assurance that capital investments in the land could be regained whenever they severed connections with

their farms. Two methods were proposed to furnish this assurance: (1) incorporating provisions in the farm lease to compensate tenants for the unused benefits of their investments in the land when they move, and (2) more careful appraisal of land for sale so that soil disinvestments as well as erosion control accomplishments are reflected in the sale and purchase prices of the land.

The solution to the problems revealed by this investigation was not complete because the alternative means for overcoming the obstacles and resistances had not been tested and tried in the area. However, this investigation did help lay the groundwork for the solution of the problems by delimiting and diagnosing some of the major obstacles to erosion control. A knowledge of the obstacles and the means for overcoming them would provide the basis for an education program in soil erosion control. Not only would this educational program help farm operators overcome the basic obstacles and resistances, but it would help both farmers and program administrators reappraise their erosion control objectives, and the means whereby they may be more fully achieved.

DECAY AND CAPTURE OF MESONS IN PHOTOGRAPHIC EMULSIONS¹

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Meson events have been studied in Eastman NTB-3 plates which were exposed to cosmic radiation in the stratosphere by means of meteorological balloons. A systematic search has been made for meson tracks which stopped in the emulsion. Meson tracks were distinguished from proton tracks by the amount of small angle scattering and the rate of change of grain density with residual range.

A total of 659 meson tracks were found which stopped in the emulsion. Of these

mesons, 500 are mesons which stopped in the emulsion without associated tracks other than electron tracks, 118 are negative π mesons which end in stars, and 41 are π - μ decays. It is known that 26.8 per cent of the negative π mesons which stop in photographic emulsions do not produce stars. Of the 500 mesons, only 462 stopped in plates suitable, from sensitivity consideration, for observing the decay electrons. Of these 462 mesons, presumably 422 are μ mesons. The decay electron track was observed from 122 of these mesons. Only the electron tracks which were nearly in the plane of the emulsion could be seen. The number of decay electron tracks which were not seen was estimated from the angular distribution of the observed electron tracks. It is estimated that 288 ($68 \pm 7\%$) of the μ mesons decayed in the emulsion. This

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result is in agreement with crude theoretical calculations.

In 58 cases, one or more electrons in the energy interval from 15 to 70 k.e.v. were observed from mesons which stopped in the emulsion without associated particles other than electrons. In 10 cases two electrons in this energy interval were observed from the same meson. In 2 cases, three electrons were observed from the same meson. The energy distribution of these electrons can be represented by the equation $N(E) \sim \exp. (-E/E_a)$ where E_a is an average energy which has the value of about 17 k.e.v.

A clump of silver grains was observed at the end of 32 meson tracks. One or more low energy electron tracks were observed from the end of 27 of the 32 μ meson tracks which exhibited the clumps. It is thought that the clumps are due to one or more electrons with energy less than 15 k.e.v.

Low energy electron tracks were also observed to originate from 22 out of a total of 118 negative π meson stars. The energy distribution of these electrons was found to be about the same as the energy distribution of the electrons from the μ mesons.

The capture of negative π mesons in photographic emulsions does not lead to residual nuclei which are β active ($E >$

0.2 m.e.v.) since no minimum ionizing tracks were seen from 118 meson stars.

The ratio of positive to negative π mesons which stopped in the emulsion was found to be $(118/41) \cong 2.9$.

Nuclear track plates were exposed to monoenergetic groups of 20, 30, and 50 k.e.v. electrons. The mean ranges of these electrons were found to be 3.7, 7.0 and 17.5 microns respectively. An estimate of the energy resolution of the emulsion for low energy electrons was obtained from the apparent spread in energy of the monoenergetic electrons. For 20, 30 and 50 k.e.v. electrons the apparent energy spread was found to be ± 4 k.e.v., ± 4 k.e.v., and ± 6 k.e.v. respectively.

Essentially all of the low energy electrons from mesons are observed from mesons which did not decay. The percentages of low energy electrons that are associated with negative π mesons and with negative μ mesons are the same within the statistical limits. Also the energy distribution of the low energy electrons associated with negative π mesons is about the same as the energy distribution from negative μ mesons. These facts indicate that the low energy electrons are due to the interaction of the mesons with the electronic shells of the heavy atoms in the emulsion, rather than a nuclear phenomenon.

PRODUCTION OF BOTTOM FAUNA IN THE PROVO RIVER, UTAH¹

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The Provo River, Utah, a rather typical mountain stream of the Intermountain Region, was studied between September 15, 1946 and May 28, 1949 with particular reference to the ecological factors which were correlated with the rich productivity of invertebrate animals in the river. Various physical, chemical, and biotic factors which may influence the productivity of a river were measured. Special attention was given to the determination of the

quantitative and qualitative changes in the bottom fauna which occurred during the different seasons of the year.

Nine major sampling stations and six supplementary ones were selected in typical average sections of the stream. A series of 267 physical and chemical determinations were made at these stations and 384 square foot samples were taken. The average number of organisms per square foot was 193 with an average volume of 2.69 c.c. By the standards of Hazzard (1935) the Provo River rated as an exceptionally rich stream.

Since the total number of organisms taken represented many overlapping populations of individual species, representing many different but characteristic life cycles, there was considerable variation

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in the composition of the samples obtained. Even with these variations, very definite seasonal and altitudinal trends could still be detected. The period from April to June each year yielded the least number of organisms per square foot sample. The period from December to March was most productive as judged by the number and volume of organisms taken in each sample.

Considerable difference in productivity existed in the river at the higher and lower altitudes. Of 119 square foot samples taken from the upper 17 miles of the main fork of the stream, only 3 rated as being exceptionally rich. Of 100 samples taken from the lower 19 miles of the stream, 73 rated as being exceptionally productive.

The great majority (95.2 per cent) of the bottom fauna belonged to five orders of insects, the Trichoptera, Ephemeroptera, Diptera, Plecoptera, and Coleoptera. The same five orders also comprised 94.2 per cent of the total volume. The most

than these two were three mayflies, *Baetis tricaudatus*, *Ephemerella inermis*, and *Ephemerella grandis*; a stonefly, *Pteronarcissa badia*; and a beetle, *Heterolimnius quadrimaculatus*.

Throughout the course of the study the variations in color, turbidity, dissolved oxygen, and free carbon dioxide content at all of the stations and during the different seasons were so slight that those factors could not be considered significant in explaining the differences in productivity at various altitudes along the stream. The differences can best be explained on the basis of the changes that occurred in the nature of the stream bed, and in the velocity, volume, temperature, pH, and carbonate content of the water as the river descended from its lofty origin to the valley floor. The effect of these factors on the productivity of bottom fauna in the stream was best shown at the Upper Bridge Crossing and Deer Creek Park, as contrasted in the following table:

Station	Upper Bridge	Deer Creek Park
Elevation in feet	9,500	5,300
Organisms per square foot		
Average number	72	372
Average volume in c.c.	0.88	6.33
Bottom type	Large rubble	Coarse gravel and silt
Velocity in feet per second	1.5-7.5	2.0-5.9
Volume in cubic feet per second	11.3-155.2	233.2-858.4
Temperature in degrees Fahrenheit	32-63	40-57
pH	6.8-7.3	7.7-8.1
Carbonate alkalinity in p.p.m.	4.5-10.0	115.0-192.0

abundant and widely distributed organism encountered was a caddis fly, *Brachycentrus occidentalis*. This species constituted 12.3 per cent of all the organisms collected. A stonefly, *Pteronarcys californica*, comprised 22.4 per cent of the total volume. The most abundant species other

The low productivity characteristic of the river at the higher elevations in contrast to the high productivity characteristic of the river at lower elevations was associated with greater variability in velocity, volume and temperature, lower alkalinity, and lower carbonate content.

PHYLOGENETIC DEVELOPMENT OF THE INFLORESCENCE AND GENERIC RELATIONSHIPS IN THE KOBRESIACEAE¹

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Investigation of *Carex* L. and related genera, usually assigned to the tribe Cariceae in the family Cyperaceae, shows them to be morphologically as nearly related to the family Gramineae as to the other segments of the Cyperaceae. For this reason it is here proposed that the tribe Cariceae comprise a separate family—the Kobresiaceae. Although the genus *Carex* L. perhaps should be considered as the type genus of the proposed new family, the name Kobresiaceae (based upon the genus *Kobresia* Willd.) is used because the family name Cariceae is preempted for the group of plants which includes the papaya. The new family may be described as follows:

KOBRESIACEAE Gilly, familia nova.
CYPERACEAE (tribus?) ELYNEAE Nees,
Linnaea 1: 304. 1835.
CYPERACEAE (tribus?) CARICEAE
Nees l. c. 305.
CYPERACEAE (tribus?) CARICINEAE
Kunth, Enum. Pl. 2: 368. 1837.
CAREXIDES Raf. Good Book 23. *nomen
sine descriptio*. 1840.
CYPERACEAE (tribus?) CARICINEAE
Steud. Syn. Cyp. 182. 1855.
CYPERACEAE subfamilia CARICOIREAE
Pax, Bot. Jahrb. 7: 307. *pro parte*. 1886;
et Kuk. Pflanzenr. 38 (IV. 20): 1. 1909.

Herbae perennes; rhizoma caespitosum vel repens; caules plerumque enodulosi medullosi; folia tristicha graminea sessilia, vaginae clausae ore cum ligula membranacea; inflorescentia e androgynonis 2-plurifloris vel saepius abortu unifloris in spiculae dispositis composita; flores monici rarius dioici diclini; perianthium nulum; stamina in flores masculi 3 vel 2 (rarissime 4-6); filamenta libera rarissime basi connata; antherae basifixae; ovarium in flores foemini uniloculare e carpellis

3 vel 2 (rarissime 4-6) formatum prophylo marginibus antice plus vel minusve connato circumdatum; stylus unicus in stigmata 3 vel 2 (rarissime 4-6) fissus; ovulum unicum basilare anatropum; fructus indehiscens osseus vel lignosus; semen unicum erectum liberum albuminosum; embryo minutus in albumine inclusus ad basin situs—Genus typicus: *Kobresia* Willd. (Sp. Pl. 4: 205. 1805).

The principal characteristics for the recognition of this proposed new family are: (a) the perigynium, a modified prophyll, which subtends each pistillate flower and resultant fruit, and (b) the ligule at the juncture of the leaf-blade and leaf-sheath. Secondary characteristics are: (a) the unisexual and perianthless flowers, (b) the closed leaf-sheaths, and (c) the achene as a fruit.

In this study the structure of the inflorescence as a whole, and the relationship of its component parts are analyzed in 988 species of the complex. Ten developmental trends are recognized, described and evaluated; these developmental trends concern: (1) vascularization of the perigynium; (2) orifice of the perigynium; (3) occurrence of cladophylls; (4) occurrence of cryptophylls; (5) type of style and associated apex of achene; (6) complexity of inflorescence; (7) structure of inflorescence axis; (8) character of the tertiary axis; (9) arrangement of the unisexual flowers; and (10) number of stigmas.

For clarity and precision, six terms which apply to the Kobresian inflorescence are proposed as new. These terms are defined below:

(1) *Androgynon*—an inflorescence unit consisting of a short branch subtended by a bract, bearing a prophyll with an axillary pistillate flower near the base and terminated by a group of staminate flowers and attendant androphylls.

(2) *Androphyll*—the bractlet which subtends an individual staminate flower.

(3) *Compound Androgynon*—an androgynous inflorescence unit in which the axis is elongated and bears one or more complete or modified androgynons be-

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tween the basal prophyll and the apical cluster of staminate flowers.

(4) *Cryptophyll*—a prophyll borne at and surrounding the base of a secondary inflorescence axis and also enclosed by the sheath of the bract which subtends this axis.

(5) *Gynephyll*—the bractlet which subtends an individual pistillate flower.

(6) *Spicato-paniculate*—an inflorescence type in which a single pedunculate spike is borne in the axil of each primary bract along the primary axis of the inflorescence.

On the basis of combinations of the several phases of the ten characteristics corresponding to each of the above listed developmental trends, 111 (out of a theoretically possible total of 96,768) inflorescence *type-groups* are recognized among the 988 species studied; each of these *type-groups* is described, the component species are listed and the known geographical distribution is given for each group. The 111 inflorescence *type-groups* are provisionally arranged in 22 *species-groups*; on the basis of inflorescence characteristics alone, the 22 groups of species seem to merit generic status but such recognition is deferred until the vegetative characteristics of the group as a whole can be adequately studied. Each of the *species-groups* is described, so far as inflorescence characteristics are concerned; a tentative synonymy of generic names and a map showing the known geographical distribution is given for each.

The relative primitiveness (i. e., advancement value) of each *type-group* and each *species-group* was determined by assigning an arbitrary value of zero to the most primitive phase of a characteristic, a value of ten to the most advanced phase, and intermediate values to intermediate phases. The range in advancement value for *type-groups* is 13 per cent to 80 per cent, with a mean advancement value of 49.8 per cent. Mean values for *species-groups* range from 17.5 per cent to 66.5 per cent.

On the basis of the assumption that the primitive members of a group of organisms are more apt to be found living in or near the center of origin of that group, while the advanced or derived forms are more apt to be found at a greater distance from this center, the morphological characters and the known geographical distribution of the 111 inflorescence *type-groups* are integrated in an attempt to determine the distributional history of this complex of species. The conclusions reached with

respect to this phase of the problem are:

(a) the center of origin of the Kobresiaceae is in the Malaysian portion of the tropics;

(b) the primary migration tract for the group extended both eastward and westward through tropical regions from the center of origin, and the western terminus was in the area which corresponds to the present American tropics;

(c) simultaneous with the later phases of the primary migration, primary centers of development were established on the margins of the tropical zone and a secondary phase of development and migration from these centers took place;

(d) secondary migration tracts with consequent secondary centers of development were established following the primary phases of development; subsequent to the secondary migrations, tertiary centers of development were established. The tertiary migrations and attendant "explosive" speciation were influenced greatly by the Pleistocene glacial periods.

The distributional history of the Kobresiaceae agrees with the distributional history of many other family, suprafamily or infrafamily complexes. Among such complexes discussed for comparison with the Kobresiaceae are the Magnoliaceae-Winteraceae-Illiciaceae-Schisandraceae complex, the *Sorghum-Zea-Euchlaena-Tripsacum* alliance within the Gramineae, the *Crepis-Dubya-Youngia-Ixeris* alliance within the Compositae, and the infrageneric units within the family Aceraceae. On the basis of the available data with respect to geographical distribution in combination with the morphological structure, it is apparent that the Kobresiaceae is to be classed among the more ancient Angiospermae. The form ancestral to both the Kobresiaceae and the Gramineae should be sought for in or near the Malaysian center of origin. Probably it would—if still existent—be characterized by an inflorescence structure with a basic unit from which both the Kobresian androgynon and the Graminean spikelet could be derived.

Distributional data at present available for the 988 species of Kobresiaceae studied show a number of important discontinuous distributions. Particularly significant are the numerous instances of vicariads which occur to the north and the south of the tropical zone without representatives in this area between. It is suggested that such disjunctions are the result of what might be termed "parallel" evolution. Inasmuch as the major part of the genetical

potentialities of the Kobresiaceae must have been present in the ancestral form of the group, the disjunct distributional examples of parallelism represent nothing more than survival—in suitable ecological niches—of similar morphological types that have been independently derived, in part through the process of gene mutation, in the secondary and tertiary centers of development.

Our present knowledge with regard to geographical distributions of plants indicates that discontinuous distributions, as well as certain repetitive patterns of endemic distributions, such as described

for the Kobresiaceae are paralleled in many other plant families among both the Angiospermae and Gymnospermae. The correlation of such distributional patterns with the "known" facts of historical geology and zoological evolution and differentiation is quite striking. Unfortunately there is a relative paucity of karyotypic and cyto-taxonomic information with regard to the component species of the Kobresiaceae. Such information as is available for this field, however, appears to support the conclusions based upon the combined morphological and geographical evidence reported in this paper.

THE DETERMINATION OF TOCOPHEROLS IN MILK FAT¹

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Tocopherols have been considered to inhibit the autoxidative reaction in fats; it has likewise been considered that destruction of tocopherols may ensue as the fat becomes oxidized. If this were the case, the quantity of non-oxidized tocopherols present in the fat at any time should be a function of the degree of oxidation in the fat.

In general, the objectives of this study were to determine the extent to which materials in oxidizing and in normal milk fat interfered with the Emmerie and Engel (1) procedure for tocopherol determination, to devise means of eliminating interference of these substances and as a result of the two objectives, to develop a method for the determination of the residual non-oxidized tocopherol in milk fat at any time during the oxidation of the fat. It was considered that peroxides, carotene, vitamin A, and tocoquinones would interfere.

Analyses for tocopherol reported in the literature would seem to indicate that tocopherols may be the only naturally occurring antioxidants in milk fat. In this study an attempt was also made to determine whether tocopherols other than alpha were present in milk fat samples

from various sources, since it was postulated that the type of tocopherol contained in the milk fat might be a function of the type of feed consumed by the producing herds.

The method in most general use, the Emmerie and Engel method, is based on the reduction of ferric iron and the subsequent formation of a color complex of ferrous iron with α, α' -dipyridyl. Substances which interfere in the determination are removed by adsorption onto Floridin. The Kjolhede modification (2) of the Emmerie and Engel method consists of a treatment of the Floridin adsorbent with stannous chloride in order to prevent destruction of the tocopherol during chromatography. For this study, the Kjolhede Floridin preparation was further modified by washing with water subsequent to the stannous chloride treatment. This latter modification proved unsatisfactory in that the adsorbent did not remove peroxide and in some cases apparently destroyed some of the tocopherol.

The saponification procedure recommended by Emmerie and Engel was not satisfactory and was modified by increasing the alkali concentration from 2.0 to 3.5 N to obtain reproducible results, and by adding 0.5 ml. of 5 per cent pyrogallol per g. of fat to the saponification mixture to prevent destruction of tocopherol. Saponification was carried out at 70 degrees C. for a period of ten minutes after the solvent began to drip from the condenser tip.

The effects upon the analytical results

- 1 a. Chairman of Committee, Emerson W. Bird, Professor, Dept. of Chemistry and Dairy Industry, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1122. Submitted December 8, 1950.
- 2 a. B. S., Pennsylvania State College, State College, Pa., 1942.
- b. Cooperator Agricultural Experiment Station.

of the products of fat deterioration were studied. It was concluded that the Kjolhede Floridin removed peroxides, but that it reduced the tocopherol-quinones to substances which are measured as tocopherol by the Emmerie and Engel method. Saponification successfully destroyed peroxide and removed the tocopherol-quinones. Therefore, the recommended method of assay includes a saponification step and a treatment with Kjolhede Floridin.

A combination of Kjolhede Floridin with activated alumina was studied. It was considered that the tocopherols could be separated from carotenoids, vitamin A and peroxide (by means of the Floridin) and from the glyceride (by means of the alumina). This procedure was effective in the separation, but recoveries of tocopherols added to fats prior to treatment were low, indicating destruction of tocopherol by the alumina.

The Quaife and Biehler modification (3) of the Emmerie and Engel method, employing a mild hydrogenation step to remove the interference of carotenoids, vitamin A and peroxide was found to give erratic results and to reduce the tocopherol-quinones to substances which react with the reagent as tocopherol, thereby giving erroneously high results.

The different rates of reaction of the Emmerie and Engel reagent with the different tocopherols was used as the basis for a method for determining the presence of tocopherols other than α -tocopherol. α -Tocopherol reacts completely with this reagent in one minute. The other tocopherols require more than 10 minutes to react completely. It was concluded on the basis of results obtained with this method, that if γ or δ -tocopherols, are present in milk fat they do not vary significantly among samples obtained from widely varying sources and they occur in very small quantities.

The recoveries of α and γ -tocopherols added to fat prior to treatment was 100 per cent when the whole-fat was analyzed by the Kjolhede procedure, but when the non-saponifiables were analyzed the recovery was ca. 88 per cent. This low

recovery of tocopherols added to fats is not believed to be representative of the recovery of the naturally occurring tocopherols, possibly due to a faulty technique in the means of addition of the tocopherols to the fat prior to saponification since tocopherols are easily destroyed by alkalis. This is substantiated by the fact that the assay values of the saponified fat were much more reproducible than the recovery values of tocopherol added to fats when saponified. Furthermore, the assay values of the non-saponifiables of fresh fats agree well with the assay values of the whole-fats.

The method recommended for the assay of the non-oxidized tocopherol in oxidized milk fat is the Kjolhede modification of the Emmerie and Engel method. It is necessary to completely saponify the fat prior to treatment with the adsorbent. This is accomplished with 2 ml. of 3.5 N methanolic potassium hydroxide per g. of fat. The saponification must be conducted in the presence of a substance (such as pyrogallol) which prevents destruction of tocopherol in the presence of alkali. The whole fat may be analyzed in the event that it is certain that the fat is not oxidized.

The tocopherol content of 15 samples of commercial butter analyzed by the Kjolhede modification of the Emmerie and Engel method averaged 29.1 mcg. per g. of fat when the whole fat was analyzed, and 24.7 mcg. per g. of fat when the non-saponifiables were analyzed.

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FEDERAL LAND BANK LOAN OPERATIONS IN WESTERN WASHINGTON 1917-49¹

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The U. S. Bureau of the Census has reported a marked increase in part-time farming in western Washington since 1934. Although some of this increase was undoubtedly the result of increased off-farm employment opportunities during World War II, it is believed that much of this trend has been due to the continuing population growth and industrial development of the region. Other factors which have contributed to this situation are the small size of farms, the seasonal nature of certain employment opportunities, the all-weather roads, and the proximity of many agricultural areas to towns and cities. Recognizing that increased off-farm employment may have an important bearing on long-term farm loan risks, the Federal Land Bank of Spokane provided the author with the basic data necessary for a loan experience study.

Western Washington embraces 19 counties and is separated from eastern Washington by the rugged Cascade Mountains. The region is relatively new, with its greatest development having occurred since 1900. The coastline of Puget Sound and the Pacific Ocean is dotted with cities which are active ports and growing industrial centers. Principal industries include lumbering, manufacturing, fishing, and shipping. Types of farming include dairy, poultry, general, tree fruits, and truck and berries. The climate is mild the year around and is ideally suited to dairying, which is the dominant type of farming. The area is primarily a forest region and but 14.2 per cent of the land area was in farms according to the U. S. Census of Agriculture in 1944; in that year, there were reported 48,599 farms, the average size being 47 acres. Although the total number of farms has remained rela-

tively constant, the percentage of operators engaging in off-farm work increased from 46.0 per cent in 1934 to 57.3 in 1944. More significantly, farmers have been engaged in off-farm work a greater number of days each year. The percentage of total operators working 250 days or more off-farm in 1934 was only 8.7 per cent as compared with 41.0 per cent in 1944. These data suggest that off-farm employment opportunities have absorbed an increasing amount of excess farm labor; this, in turn, would imply that much of the increase in part-time farming in western Washington may reflect an adjustment on the part of rural rather than urban populations.

The method of procedure employed in the investigation was, first, to determine those characteristics of farms which appear to have a bearing on loan experience and, second, to determine and compare the characteristics of part-time and full-time farms on which loans have been made in recent years. It is hoped that the findings will prove useful in estimating the amount of risk involved in lending to part-time farmers in western Washington. It should be noted at this point that the Federal land banks are authorized to grant loans only to those part-time farmers whose normal agricultural earnings will be sufficient to meet farm operating expenses, including loan installments; further, off-farm income necessary for family living expenses must be available to a typical operator.

A total of 13,466 loans for over 39 million dollars were closed during the period 1917-49. Almost 58 per cent of these loans were closed prior to 1933, and nearly 25 per cent were closed during the years 1933-35. Lending activity declined from 1936 to June 30, 1945, but has increased considerably subsequent to that date. Tabulations of data pertaining to the 13,466 loans were greatly facilitated by the files of Hollerith punched cards which have been maintained by the Federal Land Bank of Spokane. The history of each loan has been recorded in a separate punched card.

Preliminary experimentation revealed

1 a. Chairman of Committee, William G. Murray, Professor, and Head, Dept. of Economics and Sociology, Agricultural Experiment Station, Agricultural and Home Economics Extension Service, Industrial Science Research Institute.

b. Doctoral Thesis No. 1119. Submitted November 21, 1950.

2 a. A. B., Luther College, Decorah, Iowa, 1938.
M. S., Iowa State College, Ames, Iowa, 1940.

that the following characteristics would probably be of most significance in regard to loan experience: (1) the period during which the loan was made, (2) the kind of loan, (3) the net income area³ in which the farm was located, (4) the debt load⁴, that is, the amount of debt in relation to the value of the property, (5) the number of cultivated acres, and (6) the type of farming engaged in by the borrower.

Losses on loans closed during the period 1917-32 amounted to \$43 per \$1,000 loaned. These heavy losses reflected inexperience in making and servicing loans and also the sharply declining prices of agricultural commodities in 1920-21 and subsequent to 1929. Experience was much better on loans closed during 1933-35, when no net loss was realized on Federal Land Bank loans; a loss of \$9 per \$1,000 loaned accrued on the newly authorized Land Bank Commissioner loans,⁵ and a loss of \$17 was sustained on the relatively large joint Federal Land Bank and Land Bank Commissioner loans. No losses have been sustained on loans closed subsequent to 1935.

A definite relationship was found between loan experience and net income areas. No loss occurred on loans closed during 1917-32 on net income area 1 farms, whereas a loss of \$112 per \$1,000 loaned was sustained in net income area 5. This same relationship prevailed for loans closed during 1933-35, although losses were much smaller.

Losses varied directly with the relative debt load of loans closed during 1917-32. Only 2 per cent of the farms in the light debt load group were acquired as a result of loan breakdown, whereas 21 per cent of the farms with heavy debt loads were acquired; losses ranged from \$3 per \$1,000 for the light debt load group to \$41 per \$1,000 for the heavy debt load group. These relationships continued to hold for loans closed during 1933-35.

Loan experience has been considerably more favorable on small farms than on large farms. Losses on loans closed during 1917-32 on farms with 5 cultivated acres or less were \$19 per \$1,000 loaned as compared with \$53 per \$1,000 loaned on farms with over 30 cultivated acres. Again, this same relationship was found for loans closed during 1933-35.

When loans were classified by types of farming, it was found that loans on tree fruit farms sustained the heaviest losses, while loans on poultry farms had the most favorable record during both 1917-32 and 1933-35. Loans closed prior to

1933 on dairy farms had lower losses than loans on general farms, but this situation was reversed on loans closed during 1933-35. Loan experience appears to be less directly associated with types of farming than with net income areas, debt loads, and cultivated acres.

Cross-classification of loans by cultivated acres within net income areas, debt loads, and types of farming revealed, in each instance, that the best experience was consistently found on loans on smaller farms; when loans were classified by cultivated acres and periods, it was found that the per cent of loans paid off on small farms has exceeded that on large farms in every period to date.

Since July 1, 1945, Federal Land Bank appraisal reports have designated whether a farm was a part-time or full-time unit. Thirty per cent of the loans closed in western Washington since that date have been on part-time farms. The primary characteristic which distinguished part-time from full-time farms was found to be cultivated acreage. Only 14 per cent of the part-time farms had more than 30 cultivated acres, as compared with 73 per cent of the full-time farms. No significant difference was found between part-time and full-time farms in regard to values of dwellings, ages of operators, or the number of years which operators had owned their farms prior to obtaining a loan.

Since no losses have occurred on loans closed subsequent to June 30, 1945, the only measure of loan experience was the per cent of loans which had been paid off. Fourteen per cent of the part-time farmers had paid off their loans by cash, whereas this had been achieved by only 6 per cent of the full-time farmers.

Principal outside income opportunities available to part-time farmers were work on other farms, logging, miscellaneous urban employment, and manufacturing. Several of these opportunities were available to part-time farmers in some areas.

3 The Federal Land Bank has mapped agricultural land according to five net income areas which reflect off-farm income as well as farm income. The five net income areas are scaled in accordance with the desirability of the area as a place to farm, to live, and to make money.

4 Four debt load classes were established, light, medium, medium-heavy, and heavy.

5 Land Bank Commissioner loans could be secured by either first or second mortgages. Commissioner second mortgage loans were frequently granted to supplement Federal Land Bank first mortgage loans; Commissioner first mortgage loans were ordinarily granted to borrowers who could not qualify for a Federal Land Bank loan.

The nature of the sources of outside income clearly indicated that part-time farming in western Washington is not restricted to areas adjacent to large, urban industrial centers. Appraisers estimated that operators on over half of the part-time farms would normally obtain over 50 per cent of their total income from outside sources. Outside income as a per cent of total income was highest for general farms and lowest for dairy farms.

The findings of this study indicate that part-time farmers who can qualify for

Federal Land Bank loans constitute good risks. Part-time farms on which loans have been made since July 1, 1945, have been characterized by small cultivated acreages; loans on farms with small cultivated acreages have consistently had the lowest relative losses and the highest percentage of loans paid off by cash. The continuing economic development of the region suggests that opportunities for outside income will continue to expand, thereby further reducing the risk on loans to part-time farmers.

STUDIES ON OXYGEN-CARRYING COBALT COMPOUNDS¹

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The first oxygen-carrying cobalt compound was discovered by Tsumaki during a study of secondary valence ring compounds. He observed that disalicylaldehyl-enediimine cobalt prepared by mixing simultaneously salicylaldehyde, ethylenediamine and cobalt acetate in 60 per cent ethyl alcohol turned from red-brown to black when exposed to air, and that this black material on heating produced oxygen turning to the red-brown color again.

Upon the publication of the Tsumaki work, Diehl who was studying oxygen-carrying compounds at that time turned his attention to the preparation and oxygen-carrying properties of disalicylaldehyl-enediimine cobalt. His findings are contained in considerable unpublished work by Chao and Diehl, and Hach and Diehl which were made available for this work.

The method of preparation given by Tsumaki and used with slight alteration by Chao and Diehl, and by Hach and Diehl gave oxygen-carrying materials of widely varying oxygen-carrying capacity. In this work two new methods for the preparation of oxygen-carrying materials were devised. Both are characterized by the preliminary preparation of disalicylaldehyl-enediimine, the Schiff's base of salicylaldehyde and ethylenediamine. This material was then reacted with a cobalt salt to give the oxygen-carrying material

in a form having a high oxygen-carrying capacity. The methods of carrying out the final step differ in the solvent used. In the alcohol method the solvent used was 60 per cent ethyl alcohol in which the Schiff's base and nearly two equivalents of sodium hydroxide were dissolved. The oxygen-carrying material was subsequently precipitated by the addition of a solution of a cobalt salt. Relatively low yields were obtained by this method. In the second method water was used as a solvent, the solution of the Schiff's base being effected by the two equivalents of sodium hydroxide present. The reaction with the cobalt salt proceeded the same as in the first method but the yield was considerably better, almost quantitative. The quality of the product was affected only by prolonged boiling of the solution of the Schiff's base in the presence of alkali.

Both methods were found to be general and applicable to the preparation of oxygen-carrying materials from other Schiff's bases. Once satisfactory methods for the preparation of oxygen-carrying cobalt compounds were available the study of the oxygen-carrying properties of disalicylaldehyl-enediimine cobalt were undertaken. An accurate method for the measurement of oxygen-carrying capacity was devised and the value obtained for the best preparations showed an oxygen-carrying capacity of 4.80 per cent. Chemical analyses were made on these preparations. From these analyses and the oxygen-carrying capacity it was shown that the oxygen-carrying material probably contains one-half molecule of water per

1 a. Chairman of Committee, Harvey Diehl, Professor, Dept. of Chemistry, Industrial Science Research Institute.

b. Doctoral Thesis No. 741. Submitted March 14, 1944.

2 a. B. S., Iowa State College, Ames, Iowa, 1940.

cobalt atom. The significance of this water and the stereochemical nature of the material was discussed.

An orange material appearing momentarily in the preparation was obtained by making the preparation in absolute alcohol without alkali. Although the yield was poor, enough of this material was obtained for analyses and to show that this material reacted with water to produce disalicylalethylenediimine cobalt with a high oxygen-carrying capacity.

An effort was made to show just the type of bond formed during the absorption of oxygen by measuring the magnetic susceptibility of the oxygen-carrying material before and after oxygenation. A secondary valence bond exactly like the bonds formed in the absorption of oxygen by hemoglobin was found.

The rate at which oxygen was absorbed by disalicylalethylenediimine cobalt was measured under various conditions of temperature and pressure. In this portion of the study it was found that oxygenation proceeded most rapidly at 17-23° and that an oxygen pressure of more than 950 mm. of mercury did not noticeably increase the rate of oxygenation. The minimum time for apparently complete oxygenation was found to be about 8 minutes when adequate facilities were provided to remove the heat of oxygenation. When the conditions of temperature and pressure for deoxygenation were studied it was found that deoxygenation could be accomplished readily in a high vacuum at about 50° while increasing the opposing oxygen pressure caused the temperature required for deoxygenation to increase.

After the work on disalicylalethylene-

diimine cobalt had progressed for some time it was discovered that it had a slight hygroscopicity that complicated the study of the oxygen-carrying properties. When a little moisture was present oxygenation proceeded more rapidly, deoxygenation required slightly higher temperatures, and loss of the oxygen-carrying property increased to a measurable extent for each cycle.

Five new oxygen-carrying materials were developed using 3-alkoxy-salicylaldehydes instead of salicylaldehyde in the preparation. These materials were studied and the oxygen-carrying properties were compared with those found for disalicylalethylenediimine cobalt. In general these materials had a greater affinity for both oxygen and water than was found for disalicylalethylenediimine cobalt.

An unlimited number of oxygen-carrying materials were discovered when two or more Schiff's bases were mixed prior to the precipitation of an oxygen-carrying material by adding the cobalt salt. Seven of these preparations were studied. Such mixtures of oxygen-carrying materials were found to have less affinity for oxygen than preparations from pure Schiff's bases.

All the oxygen-carrying materials were compared on the basis of five properties: oxygen-carrying capacity, time required for apparently complete oxygenation, the oxygen pressure above which the time for oxygenation does not appear to decrease, the minimum deoxygenation temperature and the hygroscopicity of the oxygen-carrying material. The values found for each property are tabulated in the original work.

Part I—CHEMICAL KINETICS OF THE OXIDATION OF MANGANESE TO PERMANGANATE WITH PERIODATE

Part II—SOLUBILITY, ACTIVITY COEFFICIENTS AND ACTIVITY PRODUCT OF MANGANESE (II) IODATE¹

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The determination of manganese by oxidation to permanganate has been a common analytical method for some years.

- 1 a. Chairman of Committee, Don S. Martin, Associate Professor, Dept. of Chemistry, Institute for Atomic Research.
- b. Doctoral Thesis No. 1118. Submitted November 22, 1950.
- 2 a. B. S. E., University of Michigan, Ann Arbor, Michigan, 1943.
- b. Junior Chemist Institute for Atomic Research.

One of the more convenient oxidizing agents for this purpose has been periodic acid. Various investigators have reported upon preferred analytical techniques, however, little work has appeared concerning the kinetics of this reaction.

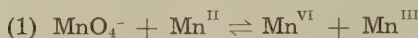
The intense color of the permanganate ion lent itself admirably to spectrophotometric measurement of the reaction progress. The Cary recording spectrophoto-

meter available for this work made possible both following the absorption peak for permanganate and also the nature of the absorption in the entire spectral region from 3600 Å to 7000 Å.

The general method adopted was to follow the formation of permanganate while holding certain variables essentially constant. The spectrophotometer limited the amount of manganese which could be used; and hence, the manganese variables could not be kept fixed. It was possible to effectively maintain the concentrations of hydrogen ion, periodate, iodate and

more complex with a minimum reaction rate at 1.5 M perchloric acid concentration. The final permanganate extinction was not a simple function of total manganese present, but instead seemed to be greater for slower reaction rates. Iodate was a variable which was an exception to this rule, the effect being to accelerate the rate and to raise the final extinction. No simple iodate order was found.

The foregoing results coupled with the information from the reaction of manganese (III) led to the postulation of the mechanism shown below:



ionic strength constant. Both manganese (II) and manganese (III) were used as the initial form for manganese.

The rate curves obtained were of two general shapes. Those with manganese (II) as the initial material were "S" shaped while those with manganese (III) as the initial form were without inflection points. This indicated that the manganese (II) reaction was more complex; hence, the manganese (III) reaction was considered first.

The reaction with manganese (III) iodate complex as the initial manganese oxidation state was found to be first and second order in manganese (III) complex and periodate, respectively. This led to postulating a mechanism involving the replacement of two iodates in the complex by two periodates followed by a first order decomposition of the substituted complex. The equations showing these reactions are given later as (5) and (6).

The manganese (II) reaction had a definite induction period which made rate measurements most convenient at the time of maximum velocity. This maximum velocity occurred quite often near the half reaction time. The orders at maximum rate for manganese (II), periodate and permanganate were one, one and one half, respectively. The effect of acidity was

The equilibria shown as (1), (3), (4), and (5) were assumed to be very rapid while the reactions (2) and (6) were taken as the means of shifting the position of equilibrium. A rate expression was derived from the above assuming that manganese (II) \gg manganese (III) \gg manganese (IV) and that at near half reaction the time rate of change of manganese (VI) was zero. The derived orders were one, one, and one-half for manganese (II), periodate and permanganate, respectively, which were in accord with the observed orders. Reaction (5) indicated that high iodate concentrations would retard the rate while smaller concentrations would accelerate the reaction because of its complexing ability. These effects were observed: Increasing ionic strength accelerated the reaction; and this effect coupled with the repression of ionization of periodate served to explain the rate minimum observed with increasing acidity. The variation of final extinction with rate was explained as precipitation of manganese (IV) oxide and periodate. Evidence for this was obtained from the absorption characteristics of the permanganate.

While preparing solutions by titrating manganese (II) with permanganate in the presence of excess iodate a purple gray precipitate was noted. Precipitation

from solutions containing manganese (III) fluoride complex with iodic acid and alcohol proved to be a superior method for the preparation of this material. Manganese determinations by periodate oxidation, iodometric oxidation equivalent determinations and analyses for iodine led to the conclusion that this material was manganese (III) iodate. A violet solution was obtained by dissolving this material in excess iodic acid indicating an iodate complex. This manganese (III) iodate complex showed an absorption maximum at about 5300 Å.

Manganese (II) iodate was noted during some kinetic studies. Reference to the literature revealed little reliable solubility

data and no activity information.

Solid manganese (II) iodate was placed in equilibrium with aqueous solutions of sodium chloride, potassium iodate and manganese (II) perchlorate at 25°. Solubility measurements of the solutions containing sodium chloride were made at 3°. Temperature-solubility data were collected in the range 3° to 90°.

The data collected made possible the calculation of the activity product, heat of solution, activity coefficients and standard entropy of manganese (II) iodate. The activity coefficients were in close agreement with those reported by electromotive force measurements for manganese (II) chloride.

SOME ORGANOMETALLIC COMPOUNDS CONTAINING REACTIVE FUNCTIONAL GROUPS¹

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In connection with the subject of this work, a literature survey concerning the preparation of organometallic compounds containing reactive functional groups was presented. A comprehensive tabulation of the organometallic compounds of magnesium, lithium, sodium, and potassium containing reactive groups has been prepared.

n-Propyllithium in diethyl ether was employed as the reagent of choice for effecting the halogen-metal interconversion reaction. A solution of *n*-propyllithium when stored 3, 7, 12, and 28 days at 10°C. showed the following reduction (per cent) in titer: 6.4, 10.1, 15.0, and 24.1, respectively. The storage of *n*-butyllithium³ at 10°C. under slightly different conditions for 2, 5, 9, 10, 21, 31, and 62 days resulted in losses (per cent) in concentration of 7.9, 13.7, 15.4, 17.3, 32.8, 37.0, and 54.3.

Attempts were made to prepare *p*-nitrophenyllithium by the halogen-metal interconversion of *p*-nitrobromobenzene with phenyllithium and *p*-nitroiodobenzene with phenyllithium, *p*-dimethylaminophenyllithium, *n*-butyllithium, *n*-

propyllithium and ethyllithium. The reaction conditions were varied widely, but no *p*-nitrobenzoic acid was isolated, subsequent to carbonation of the reaction mixtures. The introduction of methyl groups into both positions *ortho* to the nitro group (e. g. nitrobromomesitylene and 2-nitro-4-bromo-1,3-dimethylbenzene were used) failed to suppress the oxidation-reduction reaction. Incidental to this work, interconversion and subsequent carbonation of bromomesitylene and 4-bromo-1,3-dimethylbenzene gave 39.7 per cent mesitoic acid and 68.7 per cent 2,4-dimethylbenzoic acid, respectively.

Acetalization was found to be a suitable method to protect the carbonyl group of *p*-bromoacetophenone during the halogen-metal interconversion reaction. The ethylene acetal of *p*-bromoacetophenone (b.p.

134-35°/12 mm., n_D^{20} 1.5560, $d_4^{20/30}$ 1.455, yield 78.5 per cent) was prepared and treated with *n*-propyllithium to give a 30.5 per cent yield of *p*-acetylbenzoic acid, subsequent to carbonation and hydrolysis. Metallic lithium did not react with this acetal under the conventional conditions to give an organolithium compound.

The acetalization of bromophenols with dihydropyran was used for the protection of the active hydrogen during the halogen-metal interconversion reaction. In the case of 2,4-dibromophenol, the yield of 5-

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3 These data were obtained by Mr. C. G. Brannen.

bromosalicylic acid obtained by carbonation of the interconversion product was 88 per cent. The best yield of 5-bromosalicylic acid obtained from the interconversion of 2,4-dibromophenyl 2-tetrahydropyranyl ether was 32 per cent. Protection of the phenolic hydroxyl group by acetalization did not appear to be necessary or desirable. The following new 2-tetrahydropyranyl ethers were prepared: 2-bromophenyl b.p. 116-17°/0.05 mm.,

n_D^{20} 1.5473, d_{20}^{20} 1.384, yield 74.7 per cent; and 2,4-dibromophenyl b.p. 160-162°/0.2

mm., n_D^{20} 1.5774, d_{20}^{20} 1.662, yield 76.5 per cent. Attempts to prepare 2-tetrahydropyranyl ethers of 2,4,6-tribromophenol and 2,4-dibromo-1-naphthol were unsuccessful. *p*-Bromobenzoic acid did not add to dihydropyran.

Halogen-lithium interconversion of methyl *p*-bromobenzoate and methyl *p*-iodobenzoate at -78° for short reaction periods gave only traces of *p*-carbomethoxybenzoic acid subsequent to carbonation. *t*-Butyl *p*-bromobenzoate (b.p. 138-

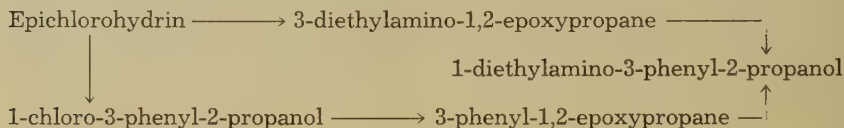
139°/12 mm., n_D^{20} 1.5240, d_{20}^{20} 1.309, yield 39.2 per cent) was prepared and treated with excess *n*-propyllithium at -40° for ten minutes to give, subsequent to carbonation, *p*-bromophenyl-di-*n*-propylmethanol (b.p. 168-172°/12 mm., n_D^{20} 1.5340, d_{20}^{20} 1.248, yield 60 per cent). The ex-

Reactions of *n*-propyllithium with phenols having two bromine atoms *ortho* to the hydroxyl group gave interconversion at one *ortho* position and reductive debromination at the other. Three equivalents of *n*-propyllithium when reacted with one mole of 2,6-dibromophenol gave, following carbonation, a 17 per cent yield of salicylic acid. Two or more equivalents of *n*-propyllithium reacted with one mole of 2,4,6-tribromophenol to give 18-36 per cent yields of 5-bromosalicylic acid, subsequent to carbonation. Propylene was shown to be a product of the latter reaction. A mechanism of reaction has been proposed.

Thirteen new alkamine ethers from 2-diethylamino-1-phenylethanol and from the heretofore unreported 1-diethylamino-3-phenyl-2-propanol were prepared. The sodium alcoholates were prepared and reacted with equivalent amounts of certain active halogen compounds in excess 2-diethylamino-1-phenylethanol and 1-diethylamino-3-phenyl-2-propanol, respectively. Tables I and II list the new amino ethers with their physical properties.

1-Diethylamino-3-phenyl-2-propanol

(b.p. 151-153°/14 mm., n_D^{20} 1.5047, d_{20}^{20} 0.957, yield 73.5 per cent) was prepared by two different syntheses, each synthesis starting from epichlorohydrin. The following sequence indicates schematically the reactions involved.



pected carboxylic acid was not obtained. The carbonyl groups in *t*-butyl esters are apparently not sterically protected toward the organolithium reagent.

The halogen-metal interconversion of 2,4-dibromophenol, 2,4-dibromophenyl 2-tetrahydropyranyl ether, 4,6-dibromo-*o*-cresol and 2,4,6-tribromophenol gave bromine-lithium exchange exclusively in the *ortho* positions.

The reaction of phenyllithium with epichlorohydrin was found to be a procedure of choice for the preparation of 1-chloro-3-phenyl-2-propanol.

Some suggestions for further work have been described. A proposed synthesis of 4-methyl-2-phenyl-1-1-(2-pyridyl)-piperazine, the cyclic analog of Pyribenzamine, has been outlined.

TABLE 1
ETHERS OF 2-DIETHYLAMINO-1-PHENYLETHANOL

Ether	B.p., °C	Mm.	n_D^{20}	d_{20}^{20}	Yield per cent
2-pyridyl	190-192	13	1.5405	1.031	53.3
2-quinolyl	190-192	0.05	1.5849	1.063	88.7
1-isoquinolyl	179-182	0.05	1.5820	1.074	83.0
benzyl	158-162	0.20	1.5360	0.991	50.8
2-benzoxazolyl	m.p. 92-93°	.....	.....	.....	7.6
2-benzothiazolyl	m.p. 76-77°	.....	.....	.....	40.0
<i>p</i> -nitrophenyl	m.p. 101-103°	.....	.....	.....	15.3

TABLE 2
ETHERS OF 1-DIETHYLAMINO-3-PHENYL-2-PROPANOL

Ether	B.p., °C	Mm.	n_D^{20}	d_{20}^{20}	Yield per cent
2-pyridyl	165	0.2	1.5344	1.015	52.7
2-quinolyl	187-190	0.04	1.5746	1.053	76.0
1-isoquinolyl	200-205	0.10	1.5722	1.052	76.0
benzyl	173	1.3	1.5353	0.995	42.0
2-benzoxazolyl	m.p. 88-89°	.....	.....	.....	50.6
2-benzothiazolyl	m.p. 74-75°	40.7

ELECTRICAL PROPERTIES OF SODIUM WOLFRAM BRONZE¹

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Department of Physics

Sodium wolfram bronze is one of a series of non-stoichiometric compounds whose chemical formula is R_xWO_3 , where R represents an alkali metal and x lies between zero and one. Hägg (1) and Straumanis (2) have shown by x-ray diffraction that the structure of these compounds is cubic and that the lattice constant decreases as x decreases from one to zero. Hägg also pointed out the remarkable changes in the color of the crystals resulting from changes in x. Concerning their electrical conduction behavior Hägg reported the bronze to be an electronic semiconductor of high conductivity between 20°C. and 350°C. Straumanis and Dravnieks (3) reported a complex conduction behavior based on a study of sintered masses. The present work was undertaken: to establish whether single crystals of the bronze exhibited metallic or semiconductor properties; to determine the sign, number, mobility and energy distribution of the charge carriers; and to predict theoretically other physical properties depending upon electronic processes.

Many single crystals of sodium wolfram bronze were prepared according to a method developed by Jellinek and Lorenz at Linde Air Products Company and reported by Jellinek and Brantley (4). A few crystals had edges as large as five millimeters, but the measurements were usually made on good cubic crystals two to three millimeters on an edge.

The experimental data required are the resistance as a function of temperature and the Hall voltage as a function of temperature. The resistance was measured by a d. c. potential method when a known electrical current was flowing in the crystal. From the resistance and linear dimensions the resistivity and conductivity of each sample was calculated. The resistance measurements were made in a cryostat over the temperature range -180°C. to 40°C. The most successful electrical contacts were made by tightening the crystal

between layers of indium, which could be forced into the shape of the crystal face. Readings of potential across the crystal were taken with current flowing in both directions to eliminate spurious thermal effects arising in either the holder or in the indium contacts. Measurements on three crystals gave for the conductivity at 0°C. an average value of $(5.3 \pm 0.7) (10^6) \text{ ohm}^{-1}\text{cm}^{-1}$, and for the temperature coefficient of conductivity an average value of $-(2.1 \pm 0.4) (10^{-3})/\text{degree}$. Thus, the crystals exhibit a conduction behavior similar to that of metals in contrast to that of semiconductors or ionic crystals.

The Hall voltage measurements were made with a constant magnetic field, and an alternating current of ten cycles per second through the crystal. Currents up to twelve amperes rms. were available from a rotary converter. A crystal holder was constructed which held the crystal and lead wires rigidly, and which supported the three sharpened wolfram wires which served as the Hall probes. Two probes, placed near each other on one side of the crystal, were connected through a helipot. A single probe was placed on the opposite side of the crystal. The Hall voltage from these probes was fed through a low frequency transformer into a narrow-band ten cycle amplifier and then into a voltmeter. With zero magnetic field the center tap in the helipot was set to a minimum signal, and then the voltage readings were made with the excited magnetic field. An average was made of the voltages produced by the magnetic field as its polarity was reversed. The Hall coefficient was determined to be $(-5.3 \pm 0.8) (10^{-4}) \text{ cm}^3/\text{coulomb}$. The effect of temperature on the Hall coefficient was small further indicating the metallic nature of the bronzes. Confidence in the apparatus was obtained from measurements of the Hall coefficients of copper and magnesium which agreed well with values from the International Critical Tables (5).

To obtain the sign of the Hall coefficient the a. c. Hall voltage and an a. c. voltage across a resistance in series with the crystal were introduced to an electronic switch and thence to an oscilloscope. By comparing the phase relations of these two signals with the corresponding two

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signals for antimony, which was determined to be positive by a d. c. method, the sign of the Hall coefficient was definitely established to be negative. Therefore, conduction is primarily by electrons rather than by holes.

From the Hall coefficient the concentration of conduction carriers (electrons) is calculated to be $(1.18)(10^{22})$ electrons per cubic centimeter. From known data on the molecular weight and density and a quantitative chemical determination of x, the density of sodium atoms in the bronze is calculated to be $(1.20)(10^{22})$ atoms per cubic centimeter. From these results one arrives at the important conclusion that each sodium atom entering the crystal donates its valence electron to the conduction process.

Having experimental values for the conductivity and the Hall coefficient, other electronic properties can be calculated from the free electron theory in metals. The properties and their calculated values are as follows: mobility of the electrons, $2.8 \text{ cm}^2/\text{volt-sec.}$; mean free path, $(17)(10^{-8}) \text{ cm.}$; magnetic susceptibility (based on the Pauli theory of paramagnetism in simple metals, $0.51(10^{-6})$; Fermi energy level, 1.9 electron volts; thermal conductivity (related to the electrical conductivity through the Wiedemann-Franz law), $0.0084 \text{ cal./cm.-sec.-degree at } 0^\circ\text{C.}$; electronic specific heat, $(2.3)(10^{-4}) \text{ RT erg./mole-degree}$, in which R is the gas constant and T is the absolute temperature; and the average thermal velocity, $(6.3)(10^7) \text{ cm./sec.}$

The magnetic susceptibility of sodium wolfram bronze has been measured by Stubbin and Mellor (6), who report a

result of $(0.45 \pm 0.03)10^{-6}$. This agreement with the calculated value lends evidence to the validity of all the theoretical calculations. The mobility and the mean free path are low in comparison with most metals. Qualitatively, this may result from the deep potential well produced in the periodic potential by the wolfram ion which has a high charge and a large mass.

An interesting continuation of this work would consist of the following experiments: (1) Similar measurements could be made on crystals which contain other sodium concentrations. (2) The conductivity curves could be extended to higher temperatures by designing electrical contacts not subjected to the limitation imposed by the low melting point of indium. (3) Experimental measurements of the Fermi energy level, thermal conductivity, and electron specific heat would provide further checks on the validity of applying the free electron theory to these crystals.

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I. STRUCTURE OF LANTHANUM SULFATE ENNEAHYDRATE

II. THE DICARBIDE ION IN INORGANIC CHEMISTRY¹

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I. Structure of Lanthanum Sulfate Enneahydrate

The structure of $\text{La}_2(\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$ has

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- b. Doctoral Thesis No. 1053. Submitted June 3, 1950.
- 2 a. B. S., University of Arkansas, Fayetteville, Arkansas, 1943.
- b. Junior Chemist Institute for Atomic Research.

been determined using X-ray data. The hexagonal unit cell, containing 4 stoichiometric molecules, has the dimensions: $a_a = 10.98$, $c_c = 8.13 \text{ \AA}$. All of the X-ray data are consistent with the space group $C6_3/m$. Approximate positions of the atoms (other than hydrogen) were determined by the use of various Patterson syntheses, and the parameters were refined using various Fourier syntheses.

There are two kinds of La atoms with completely different coordination poly-

hedra. One is surrounded by 9 oxygen atoms, 6 water and 3 sulfate oxygens, forming a polyhedron consisting of 18 equal edges. The other type of La atoms is surrounded by 12 sulfate oxygen atoms in a distorted cubic closest packing arrangement about the La atom.

One-third of the water molecules are not coordinated with the La atoms but rather fill in holes in the structure. They must be held in place by hydrogen bonding to the sulfate oxygen and water oxygen atoms, but the parameters of the oxygen atoms have not been determined with the accuracy required for predicting the actual location of the hydrogen bonds.

II. The Dicarbide Ion In Inorganic Chemistry

The complete structure of ThC_2 has been determined using single crystal X-ray diffraction data to determine the space group and the Th positions, and neutron diffraction powder data to locate the C positions. The crystal is monoclinic, not tetragonal, as previously reported, and contains 4 ThC_2 groups per unit cell. The

unit cell dimensions are: $a_0 = 6.53$, $b_0 = 4.24$, $c_0 = 6.56$ Å, and $\beta = 104^\circ$. All of the X-ray and neutron diffraction data are consistent with the space group C2/c .

The C-C distance, while not accurately determined, is of the order of 1.5 Å, and not 1.2 Å, the distance expected for a C_2^{2-} ion. In addition, the Th-C bond distances, some of which are as short as 2.3 Å, indicate covalent rather than ionic bonding. Thus it is not reasonable to consider ThC_2 as containing C_2^{2-} ions.

The arrangement of the Th atoms about the C_2 group is similar to that of the H atoms in ethylene. However, each Th atom, while strongly bonded to only one carbon of the C_2 group, is also weakly bonded to the other carbon, and thus the ethylenic arrangement is distorted. The arrangement of carbon atoms about the Th atoms is essentially octahedral with 4 of the octahedral positions occupied by C_2 groups as a whole, and the other 2 positions each occupied by only one carbon atom.

The salt-like dicarbides have been discussed briefly in the light of the ThC_2 structure.

VECTOR POWER DISTRIBUTION IN ELECTRICAL NETWORKS¹

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The transformer is one of the fundamental pieces of equipment used in alternating-current electric power networks. One of the properties of a transformer is its ability to control the flow of real and reactive power (vector power) on interconnected polyphase power systems of the loop type. Unfortunately certain classes of circuit problems of this type have been troublesome of solution.

Circuit problems which involve closed loops in which the product of all of the transformations in the loop fails to produce the value of real unity may be very tedious to solve. This is because all of the

circuit parameters cannot be referred to a common base value. The reduction of all quantities to values expressed in terms of a common base value provides a shortcut to the analytical solution of the majority of power system problems.

Circuit problems which involve phase transformations have in the past proven awkward to solve by means of a network analyzer, because phase transformations are not representable with ease on a network analyzer.

The purpose of the work described in this thesis has been two-fold. The first purpose has been to determine a simpler, more facile method for the analytical solution of loop circuits which involve general vector transformations. The second and companion purpose has been to develop a device which will produce phase transformations in a network analyzer circuit, and which will thereby allow circuit problems complicated by general vector transformations to be solved on a

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network analyzer with reasonable ease.

The discovery that a transformation can be represented by an equivalent circuit consisting of two generators has made possible an approach to the solution of both of the problems that have been posed.

A transformer may be regarded as a three-terminal network. Only the perfect transformer need be represented by the two-generator equivalent. The imperfections of a transformer are easily and conventionally represented in terms of equivalent impedances which may then be associated with the portion of the network external to the transformer.

Of the two generators required for the two-generator representation of a transformation, one must be a voltage generator and one must be a current generator. The voltage generator, a series element, must supply the vector voltage difference ΔE_p produced by the transformation. If the vector voltage transformation constant is denoted by A then Δ is evidently equal to $A - 1$. The current generator, a shunt element, must supply the difference in current δI_p which exists between the input current and output current of the perfect transformer as a result of the transformation. The value of δ in the case of a general vector transformation has been shown in the thesis to have the value

$(-1 + e^{j2a}/A)$. In this expression a is the angle of the vector transformation.

Certain types of problems may be solved with relative ease by the use of the two-generator equivalent of a transformer. One of these problems is that of determining the change in behavior of a system upon the introduction of a single vector transformation. The circuit including whatever impedances may be introduced by the transformer is first solved to determine its behavior without the perfect transformation. The circuit is next solved for its response to only the two equivalent generators which produce the perfect transformation. The results of this latter solution may be added to those of the initial solution to give the final values for the circuit operation conditions, as they exist after the transformation has been introduced.

The expressions given earlier for the general transformation reduce to even simpler forms for those less general types of vector transformation which are known as the pure magnitude transformation and as the pure phase transformation.

The pure magnitude transformation is the type most frequently encountered as almost all transformers produce only

magnitude transformations. For the pure magnitude transformation δ has the value $(1 - a)/a$ where a is the transformation ratio of the transformer. The constant Δ has the value $a - 1$.

While the pure phase transformation is rarely encountered, the particularly great simplicity of the relation that must exist between the two generators of the two-generator equivalent circuit is of especial significance in this case for network analyzer work. For the case of a pure phase transformation the simple relation holds that $\delta = \Delta$. An analysis of Δ reveals that it is of the form $2 \sin a/2 e^{j(\pi/2 + a/2)}$. A phase transformation of a degrees is therefore readily produced if a fraction $2 \sin a/2$ of the input voltage is introduced at an angle of $(\pi/2 + a/2)$ with the input voltage. Identical steps must be taken with regard to the input current.

In the case of modern high-frequency network analyzers the required voltage generator may take the form of a vacuum-tube amplifier of low output impedance. The required current generator may take the form of a vacuum-tube amplifier of high output impedance. As indicated above when these amplifiers are excited by their respective values of primary voltage and current by means of a voltage divider and phase-shifting network such that their output is $2 \sin a/2 e^{j(\pi/2 + a/2)}$ times their input the two-generator equivalent will produce a phase transformation of a degrees.

A two-generator equivalent of this type was built and tested on the Iowa State College network analyzer. It was designed to produce phase shifts in the range of -15° to $+15^\circ$. This form of phase transformer was found to function effectively over its entire load range.

The greatest source of error in such a phase transformer is from that error which arises because of the inherent internal series resistance of the vacuum-tube voltage generator and because of the inherent shunt conductance of the vacuum-tube current generator. Despite this error the transformer, by virtue of its active sources, may be adjusted to behave as a perfect transformer if small individual adjustments are made on the controls of the transformer. Operating under such conditions the phase transformer operates with the terminal conditions of a truly lossless device.

In practice the transformers which must be simulated have losses of their own, and the losses of the network analyzer representation may be used in representing the

losses of the actual transformer whose circuit effects are under evaluation.

A general vector transformation may be synthesized from its two component transformations—the magnitude transformation and the phase transformation. Accordingly, it is only necessary to cascade a phase transformer of the two-generator type with an ordinary magnitude transformer to produce a general vector transformation.

This work has shown that any trans-

former may be represented by an equivalent circuit consisting of two generators. It has been found that this method of representation provides a new and sometimes simpler approach to the analytical circuit solution of networks involving transformations.

It has also been found that this two-generator method of representing a transformation provides a useful and convenient tool for producing vector transformations in network-analyzer circuits.

THE DETERMINATION OF GAMMA-RAY ENERGIES WITH THE MAGNETIC LENS SPECTROMETER¹

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An iron-free thin magnetic lens beta-ray spectrometer has been constructed. The spectrometer is mounted with its axis parallel to the earth's magnetic field.

The vacuum chamber consists of an aluminum tube 100.9 cm. long, 17.8 cm. outside diameter and 0.32 cm. wall thickness. Appropriate baffles are placed in the vacuum chamber to define the trajectories of the electrons. A 2-inch O. D. brass tubing, in which the Geiger-Mueller counter is mounted, passes through a Wilson seal at one end of the vacuum chamber. In this way the Geiger-Mueller counter can be placed at any desired position along the axis of the spectrometer. At the other end of the vacuum chamber is mounted a modified gate valve, which is vacuum tight, and another Wilson seal. The radioactive source is mounted on the end of a 2-inch O. D. brass tubing which passes through the Wilson seal. This permits the radioactive source to be placed at any desired position along the axis of the spectrometer. By means of the vacuum tight gate valve the radioactive source may be replaced by another source within a few minutes without seriously

disturbing the vacuum in the main chamber. The vacuum chamber is evacuated by means of a 4-inch oil diffusion pump and a Cenco Hypervac forepump. These pumps maintain a pressure of about 2×10^{-5} mm. of Hg.

The magnet coil has an inside radius of 9.9 cm., an outside radius of 28.3 cm. and an axial length of 10 cm. The coil consists of 2,799 turns of #12 single cotton enameled copper wires. These 2,799 turns are divided into 18 separate coils so that any combination of the coils may be used, depending on the energy of the radiation being studied. With 220 volts on the coil and the source and counter each 50 cm. from the center of the coil, the spectrometer is capable of focusing electrons of about 3.4 Mev energy. By means of an electronic control circuit the current in the coil is held constant to within a probable error of 0.1 per cent.

Since the spectrometer is iron-free, the momentum of the focused electrons is proportional to the current in the coil. Let $H\rho$ be the momentum of the focused electrons, in gauss-cm., and I the current in the coil, in amperes, then

$$H\rho = kI, \quad (1)$$

where k is a constant depending on the shape and number of turns in the coil and the positions of the object and image. The momentum $H\rho$, in gauss-cm., is defined as mv/e , where m is the relativistic mass in gm., v the velocity in cm./sec. and e the

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charge in e.m.u. The equation giving the relation between the kinetic energy E , in Mev, and the momentum $H\rho$ is

$$E = \sqrt{0.261 + 8.99 \times 10^{-3} (H\rho)} - 0.511. \quad (2)$$

Equations (1) and (2) are used in the calibration of the beta-ray spectrometer and in the calculations of energies.

The spectrometer must be calibrated by means of a gamma-ray the energy of which is known accurately. The instrument was calibrated with the annihilation radiation (0.511 Mev) from Zn^{65} .

The gamma-ray energies of Zn^{65} , Co^{60} and Se^{75} were determined. The gamma-rays from these substances ejected photoelectrons from thin lead radiators varying in surface density from 29.7 to 42.5 mg./cm.². In the case of Se^{75} the spectrum was also determined from electrons produced by internal conversion.

In order to calculate the energies of the gamma-rays from the energies of the photoelectrons which are focused in the spectrometer, there are three corrections which must be applied. One correction is the binding energy of the electron in the shell of the atom from which it was ejected. A second correction must be made for the surface density of the radiator. The third correction is that due to the earth's magnetic field.

The gamma-rays passing through the lead foil radiator produce approximately the same number of photoelectrons at all points in the foil. The electrons produced on the side of the foil facing the radioactive source must pass through the entire foil in order to reach the counter. In passing through the foil these electrons lose a certain amount of momentum. The electrons produced on the side of the foil facing the counter will not pass through

any part of the foil in reaching the counter and hence will have the maximum momentum. Due to this spread in momentum the peak of the photoelectron line will be shifted to a lower momentum value. The momentum spread which the spectrometer will accept is equal to $2KP_0$, where P_0 is the momentum of the electrons focused on the window of the counter and K is the resolution of the spectrometer in terms of half-width, which is defined as the width of the transmission curve at the point of one-half the maximum intensity, expressed in units of momentum, divided by the momentum of the peak of the curve. The corrections for the radiator may be summarized as follows. When the momentum spread which the spectrometer will accept is greater than the momentum spread produced by the foil then the shift in the peak is one-half the momentum spread due to the foil. When the momentum spread which the spectrometer will accept is less than the momentum spread produced by the foil then the shift in the peak is KP_0 , where P_0 is the momentum of the peak of the line. These corrections for the radiator are also applicable to a source of internally converted gamma-rays.

The correction due to the earth's magnetic field, which is parallel to the axis of the spectrometer, is made by correcting the observed value of the current required to focus electrons of a particular momentum. This correction is independent of the current in the coil, but does depend upon the number of coils used. This correction is equal to one-half the shift in the current value of a peak when the current in the coil is reversed.

The energies of the gamma-rays of Zn^{65} , Co^{60} and Se^{75} , as determined in this investigation, are given in Table 1.

TABLE 1*
GAMMA-RAY ENERGIES OF Zn^{65} , Co^{60} AND Se^{75}

Gamma-ray	Zn^{65}	Co^{60}	Se^{75}
	Mev	Mev	Mev
1.	1.106	1.156	0.097
2.		1.321	0.122
3.			0.137
4.			0.265
5.			0.400

* The probable error is estimated to be 1 per cent.

Other investigators have reported a value for Zn^{65} (1.14 Mev) greater than that for the lower energy of Co^{60} (1.10 Mev). The results obtained in the present investigation give a higher value to Co^{60} (1.156 Mev) than to Zn^{65} (1.106 Mev). To

compare these energies directly a source was prepared consisting of both Zn^{65} and Co^{60} . The spectrum obtained showed conclusively that the energy of the gamma-ray from Zn^{65} is less than the lower energy gamma-ray from Co^{60} .

ECONOMICS OF CROP ROTATION¹

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Department of Economics and Sociology

The specific problem in this study was to determine for the erosive Ida-Monona soils of western Iowa:

1. The profitability of alternative soil management systems as a means of attaining different levels of soil conservation or soil productivity.
2. The extent to which maximization of profits by the individual farmer are compatible with the maximization of social welfare.
3. The relative stability of net returns over time from various crops and cropping systems.

Experimental crop rotation data from the Morrow Plots, Urbana, Illinois, the Fry Farm, Wooster, Ohio, the Agronomy Farm, Ames, Iowa, and the Clarinda Experimental Farm, Clarinda, Iowa, indicated that in some instances grain and forage were complementary in terms of output. In other instances grain and forage were found to be competitive as product outputs. The Morrow Plot experiments indicated that treatment may be more effective in increasing total grain output than in combining forages with grain in a rotation. In measuring the yield-increasing effects of legumes on grain yields, a comparison of continuous corn and COM at the Clarinda Experimental Farm showed that a period of nine years was required before the annual total grain output from the COM rotation surpassed that of continuous corn. This was

the length of time required for complementarity between grain and forage in terms of output to be established. Sacrificing grain output in the short run in order to obtain a larger total output of grain at a later date has important implications from the standpoint of adopting soil conservation measures because waiting costs may be too high for some farmers.

The existence of complementary and competitive ranges between grain and forage as product outputs has important implications in maximizing long-run net income to farmers and in maximizing the social product. Neither can be maximized within the complementary range. Within the competitive range the optimum combination of grain and forage is determined by the point where the marginal rate of grain-forage substitution is inversely proportional to their price ratio.

On the basis of yield estimates output was computed for the following soil management systems for the Ida, Monona, and Napier soils in western Iowa: CCO, CCOs, COs, COsCOMM, CCOMM, COMM, COMMM, and COMMMM alone and in combination with terracing, contouring, and commercial fertilizer treatment. Both cash-grain and livestock systems of farming were assumed. The yield-increasing effects of sweet clover were reflected in relatively higher total grain outputs for CCOs and COs than for CCO when rotations were considered alone. When the rotations were combined with practices and treatment, CCO indicated a relatively larger total grain output than COs. In the rotations where meadow was left down to produce hay, forage was competitive with grain in terms of output in all instances. When crop rotations were combined with contouring, terracing, and commercial fertilizer treatment, the amount of forage gained for a given sacrifice in grain output

- 1 a. Chairman of Committee, Earl O. Heady, Professor, Dept. of Economics, Agricultural Experiment Station.
b. Doctoral Thesis No. 1110. Submitted August 25, 1950.
- 2 a. B. A., Buena Vista College, Storm Lake, Iowa, 1938.
M. S., Iowa State College, Ames, Iowa, 1942.
b. Assistant Professor, Dept. of Economics and Sociology and Agricultural Experiment Station.

was increased. Net returns were computed for the various soil management systems at three different price levels, 1920, 1940-44, and 1947. When 1920 prices were used, the crop rotations with the largest proportions of forage relative to grain had the highest net returns. When 1947 prices were used the all-grain rotations netted the highest returns. When the 1940-44 prices, which reflect the 1917 to 1948 grain-forage price relationship, were used, the following soil management systems appeared to be the most profitable on a given farm whose soil resources consist of a combination of Ida, Monona, and Napier soils:

1. Under a cash-grain system of farming, where the practices of contouring, terracing, and treatment with commercial fertilizer are not combined with cropping systems, (a) seed the Ida soil to alfalfa-brome and let it revert to native grass because gross returns from farming it are less than costs. Resources used here could be used more profitably on Monona and Napier soils, and (b) on the Monona and Napier soils, assuming that there is a market for both grain and forage, adopt one of the following rotations—COsCOMM, CCOMM, COMM or COMMM. If there is no market for forage, CCOs would be the most profitable.
2. Under a livestock system of farming (meaning that the livestock manure is returned to the soil) but again with cropping systems alone, (a) if resources are not fully utilized on the Monona and Napier soils, some returns on otherwise idle resources could be obtained on the Ida soil by adopting either a CCOs or COs rotation and (b) on Monona and Napier soils, the choice would be among the rotations of COsCOMM, CCOMM, COMM or COMMM.
3. Under a cash-grain system of farming, where the cropping systems are combined with the practices of contouring, terracing, and fertilizer treatment, (a) COsCOMM, CCOMM, COMM or COMMM offer the best alternatives on the Ida soils and Napier soils, the alternative of CCOs may be added.
4. Under the assumption of a livestock system of farming, again where the cropping systems are combined with practices and treatment, (a) the choices on Ida range from COsCOMM to COMMM with some preference given to

COsCOMM and CCOMM on the basis of the existence of diminishing marginal rates of substitution of forage for grain in livestock production and (b) for Monona and Napier soils the choices are the same as for Ida.

Generally, the soil management systems that appear to offer the best long-run profit opportunities are COsCOMM, CCOMM, COMM, and COMMM in combination with contouring, terracing, and fertilizer treatment under a livestock system of farming. However, under a cash-grain system of farming in the absence of a market for forage or if such market is relatively uncertain, CCOs with practices and treatment would be the most profitable choice.

The soil management systems that appear to offer the best opportunities for maximizing long-run net income on Ida, Monona, and Napier soils may or may not reduce soil losses to the level regarded as desirable by society.

An analysis of income variation from crop production from 1917 to 1947 showed that prices received by farmers appeared to contribute most to total income variation, crop yields appeared to rank second in importance, and costs appeared to contribute least to total income variation.

Analysis of income variation from corn, oats, and hay production on the Ida-Monona soils in western Iowa indicated that a relatively greater income variation would appear to be associated with corn and hay production than with oats production. In terms of risk and uncertainty arising from crop production, the manner in which low, average, and high incomes are apt to be distributed over time may be as important as the variation in income itself. The analysis indicated that if the distribution of incomes in the past for oats were to be used as an estimate of the future, losses of about 50 cents per acre to \$4 per acre would be expected in 20 years out of 31. Gains of about \$1.40 to about \$7 per acre would be expected in only 11 years out of 31. Thus losses would be expected in most years and relatively small returns would be expected in others. A more efficient use of resources might be obtained either by reducing oats acreage to the minimum necessary as a nursecrop to legume seedings or by shifting to a nurse crop that will bring higher returns than oats.

If the distribution of incomes in the past for corn were to be used as an estimate of the future, returns ranging from losses of about \$2 per acre to gains

of about \$7 per acre would be expected in 16 years out of 31. In 7 years out of 31, returns of about \$17 per acre would be expected, but the chances of getting returns of either \$27 or \$37 would be relatively slight. Since gains of \$17 per acre would be expected to occur as frequently as losses of about \$2, a relatively large degree of uncertainty appears to exist in corn production, particularly if production plans and plans for living are based on expectations of a \$17 per acre return and losses are realized instead.

If the past distribution of incomes from alfalfa were used as an estimate of the future, returns of about \$17 per acre would be expected in 7 years out of 32; in 7 years out of 32, \$39 would be expected. About \$8 per acre would be expected in 5 years out of 32, and in 5 years out of 32, about \$28 would be expected. On this basis, the formulation of income expectations and production plans for alfalfa would be difficult.

If corn, oats, and hay are combined in a crop rotation, the data from western Iowa suggest that the relatively greatest income variation might be expected from those crop rotations that have the largest proportions of corn and hay. Parameters of frequency distributions for mean net incomes per acre from different cropping systems at the Agronomy Farm, Ames, Iowa, appear to substantiate this further. Of the four cropping systems C, CO,

CCOM and COM, the latter two appear to have the greater income variation. However, on the basis of the past frequency distribution of mean net incomes, the rotations of CO and COM appear to be more risky than C or CCOM since losses or small gains would be expected in most of the years and relatively large gains would be expected infrequently.

A comparison of the two cropping systems, C and COM, on the Clarinda Experimental Farm, 1933 to 1948, suggest that one of the effects of obtaining a higher level of productivity by combining forage crops with grain crops in a rotation might be that of a relatively greater income variation, but if production and living plans can be adjusted to this, incomes may be expected to average higher for COM than for C in this given situation.

Parameters of historical frequency distributions are not to be regarded as those that will exist for the future because in a dynamic environment, where change is the order of things, circumstances that prevailed in the past cannot be expected to be repeated in the future. But a knowledge of what yields, prices, costs, and incomes occurred in most years, in some years, and in very few years historically may be of some help in closing the gap between expectation and realization and thereby reducing individual farmer and social losses.

TECHNIQUE FOR DETERMINING THE PROFESSIONAL INTERESTS OF HOME ECONOMISTS¹

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The complexity of the problem of relating a vocational choice to interests and the inadequacy of subjective analysis of interests as a basis for vocational choice necessitate the use of interest inventories. General interest inventories currently employed have been found to have limited

usefulness in the individual guidance of home economics students. For this reason, the need for a special inventory in the field of home economics is recognized by vocational counselors. Such an inventory would be used to identify the vocational interests of a student with the interest pattern of one or more occupations in which home economists are employed.

The present study is the first of a series of studies planned to meet this need. The ultimate objective is the development of a technique which will give maximum differentiation among occupational groups within the field of home economics. This involves the development of an inventory.

- 1 a. Chairman of Committee, Hester Chadderdon, Professor, Dept. of Home Economics Education, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1097. Submitted July 29, 1950.
- 2 a. B. S., University of Minnesota, Minneapolis, Minnesota, 1934.
- M. S., *Ibid.*, 1944.
- b. Instructor, Dept. of Home Economics Education.

of scoring keys, and of a scale for each occupation. This scale would be used to relate the sum of the weights on the occupational scoring key of a student to the total scores of persons employed in the occupation.

The development of the inventory and scoring keys for ten occupations in the field of home economics was based on the professional interests of home economists. It was assumed that interests and aversions which are peculiar to an occupational group should be determined for use in selecting inventory items and for developing tentative scoring keys.

Items for the trial form of the home economics interest inventory were secured from three sources: job analyses made by interviewing professional persons and reading vocational guidance literature, data collected in a previous study of interests of home economics students, and general vocational interest inventories in current use. The trial form of the inventory was considerably longer than the anticipated length of the revised inventory. The 448 items in the trial form were grouped into three sections: activities to which reactions were to be indicated on a five-point scale, job characteristics and environmental factors to which reactions were also to be indicated in a five-point scale, and miscellaneous items combined into series to be ranked in order of preference.

Ten home economics occupations were selected for study, criterion groups being made up of a sample or a census of persons employed in each of these occupations. To secure these groups a total of 1,884 inventories was mailed. Of the 1,799 inventories which presumably reached their destination, 1,175 or 65 per cent were returned. The analysis was limited to 963 cases since some occupational groups were too small for satisfactory study. Eight of the ten groups were made up of 100 persons, in the remaining two groups there were 69 and 94 persons.

A chi-square technique was selected to analyze the response to each item, but instead of the usual computation of chi-square from row and column totals one was used in which the contribution of each of the ten occupational groups to the total chi-square value was computed.

Ninety-two per cent of the 448 items in the inventory were significant at or beyond the 5 per cent level and 89 per cent were significant at or beyond the 1 per cent level. These percentages indicate that most of the items included in the trial form would be of value in dif-

ferentiating among these occupational groups.

Items from the trial form of the inventory were selected for ten scoring keys and combined with 22 additional items to form a revised inventory of 198 items. Each scoring key was made up of items which most successfully differentiated the particular occupational group from other home economists, the size of the numerical contributions of this group to chi-square values forming the most important basis for selection. An attempt was also made to balance the number of items in the various keys and to balance the number of items in each key to which persons responded more favorably and to which they responded less favorably than did other home economists.

Unit weights of 4, 3, 2, 1, and 0 were assigned to the levels of response to items selected for the tentative scoring keys. These keys ranged in length from 30 to 77 items and the maximum scores from 120 to 308.

Unique contributions of the study to the methodology of developing an interest inventory were: the use of job analyses as one important basis for determining which items should be included in the trial form of a special vocational interest inventory; the use of a relatively long trial form and the selection of those items which most successfully differentiate among groups of professional persons for the revised form; and the employment of a chi-square technique to select items for the revised form of the inventory and to select items for scoring keys.

Other investigations in the series of studies, of which the present one is a part, might well include: the development of scoring keys for occupations in the field of home economics not yet studied; the development of scoring keys for subgroups of occupations used in the present study; the development of a norm for each occupational group; and measurement of the success of differentiation between each occupational group and home economists in general and among occupational groups, using the tentative keys developed. Problems, the solutions of which are needed in order that reliable and valid inventories may be developed in any vocational area, are: the most desirable length for an interest inventory, the relation of length of scoring keys to the success of differentiation of an occupational group, and effect upon differentiation of using the responses of students rather than professional persons as the basis for developing scoring keys.

QUICK-CURING OF ORDINARY SUPERPHOSPHATE: DETERMINATION OF OPTIMUM OPERATING CONDITIONS ON A LABORATORY SCALE AND INITIAL PILOT PLANT WORK¹

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An investigation was carried out to develop a quick-curing process for the manufacture of ordinary superphosphate. A quick-curing process would have the following advantages over currently-used, storage-curing processes: (1) the product could be shipped directly, thus reducing both the storage space required and the working capital tied up in the inventory, (2) the opportunities for producing a granular superphosphate would be greater, (3) operating conditions in the mixing step could be chosen with more flexibility thus aiding in the attainment of optimum conversion, and (4) uncertainty as to production rates required would be eliminated since a final product could be produced in a matter of hours instead of the 4 to 12 weeks required by storage-curing processes.

In the present studies, superphosphate prepared from a Florida rock containing 32.4 per cent P_2O_5 and sulfuric acid, was quick-cured in a small laboratory Roto-Louvre type drier in which heated air was forced through a bed of superphosphate which was in agitation due to the rotation of the drier.

When superphosphate made from 71.8 per cent sulfuric acid and an acidulation of 1.81 pounds of H_2SO_4 per pound of P_2O_5 (typical commercial conditions) was dried to constant moisture content at product temperatures of 125–275°F., the conversion of the P_2O_5 to an available form was 83 to 84 per cent, an increase of only one or two per cent over that of the fresh material. At product temperatures above 225°F., the water-soluble P_2O_5 content of the product decreased. The free acid content did not vary appreciably with product drying temperatures. After

30 days storage at room temperature the P_2O_5 availability of the dried products increased to about 88 per cent. Control samples which were not heated had a conversion of about 97 per cent after 30 days storage at room temperature.

Superphosphate, prepared as described above, was treated with air-stream mixtures of varying temperature and composition. Increases in conversion ranging from 1 to 12 per cent over that of the fresh material were noted. In general, the largest increases were obtained when the superphosphate retained a high moisture content during the treatment. On drying, the steam treated superphosphate decreased slightly in conversion. On storage for 30 days the dried samples increased in conversion, the increase depending on the moisture content at time of storage. Superphosphate containing approximately 5 per cent moisture at the time of storage attained conversions comparable to those of the control samples.

The effect of sulfuric acid concentration on conversion of the dried superphosphate was then studied. Acid concentrations as low as 40 per cent H_2SO_4 were used for preparation of the superphosphate. The conversions of the fresh superphosphates were greater when the less concentrated acids were used. In the range of 40 to 50 per cent H_2SO_4 , the conversions of the fresh superphosphates were about 91 per cent, and those of the dried products as high as 94 per cent; as the acid concentration was increased above 50 per cent, conversions of the dried products decreased until at 71.8 per cent H_2SO_4 , it was only 84 per cent.

The effect of product drying temperatures, in the range of 125° to 342°F., on conversion of superphosphate made with 50 per cent H_2SO_4 was studied. At drying temperatures below about 250°F., a dried product having 93 to 94 per cent conversion was obtained. Above 250°F. the availability of the dried products decreased. The water soluble P_2O_5 content decreased as drying temperatures were increased above 250°F.

- 1 a. Chairman of Committee, G. L. Bridger, Professor and Head, Dept. of Chemical Engineering, Engineering Experiment Station, Institute for Atomic Research.
b. Doctoral Thesis No. 1183. Submitted June 11, 1951.
- 2 a. B. Ch. E. Rensselaer Polytechnic Institute, Troy, N. Y., 1945.
M. S., Worcester Polytechnic Institute, Worcester, Mass.; 1947.
b. Associate, Engineering Experiment Station.

A study of the effect of reactant acid temperature, in the range 70° to 202°F., on conversion of dried superphosphate made with 50 per cent H_2SO_4 showed that reactant acid temperatures above 160°F. resulted in a decrease of available P_2O_5 in the dried product.

Superphosphate made with 50 per cent H_2SO_4 using acidulation ratios of 1.59 to 1.96 pounds of H_2SO_4 per pound of P_2O_5 had conversions of 84 to 98 per cent when dried to constant moisture at a product drying temperature of 220°F.

As a result of this investigation, a process has been developed on a laboratory scale for quick-curing superphosphate which gives a product of salable chemical composition and excellent granular form. This process consists of using 50 per cent H_2SO_4 at temperatures up to 160°F. in the acidulation of phosphate rock. After solidification and disintegration the fresh super-

phosphate is fed into a Roto-Louvre drier where it is quick-cured by drying with hot combustion gases at temperatures up to 600°F. and at product temperatures up to 250°F. The finished product has a conversion of about 93 per cent and is in a granular form ready for bagging without any further treatment.

Initial tests on a pilot plant scale have been carried out. These tests have shown that superphosphate made with acid concentrations ranging from 71.8 to 50 per cent H_2SO_4 solidifies in the den in from 1 to 3 hours and that no materials-handling difficulties arise from the use of the less concentrated acid. Products of excellent granular form were obtained in these tests when acid concentrations of less than 60 per cent were used in the acidulation. Insufficient tests have been made to determine optimum operating conditions in the pilot plant.

COMPOSITION AND ENVIRONMENTAL INTERACTIONS OF A NATURAL FORESTED AREA OF CENTRAL IOWA¹

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Department of Botany

Forest composition and environmental modification were determined and correlated for a natural forest area along the Des Moines River, Boone County, in central Iowa. The area comprised portions of the Ledges State Park, and contiguous, privately-owned land which was included to obtain comparative data on changes in local climate and soils attributable to land management practices. A total of 17 forest communities, varying in density and successional development, on different degrees and aspects of slope were investigated.

White oak and shagbark hickory were the predominant upland forest species. In more limited, but also more mesic, situations, linden, red oak, and black maple were the dominant species.

On the basis of stand density, ground cover, and relative abundance of the forest floor, the site-communities were classified as closed stands or open-woods types. The former were characterized by

closed canopies, narrow crowns, presence of shrub and herbaceous strata, and a variable but usually continuous forest floor. Open-woods types, all pastured, were typified by widely-spaced crowns, scant shrub growth and tree reproduction, but heavy-weed and grass-sod covers. Of these, one type had undergone limited cultivation in the past. One additional site was entirely cleared, and was under continuous cultivation and seeding.

Ash determinations on a dry-matter basis of the litter collected in the fall and following spring were highest for linden, black maple, and hickory, being the lowest for red oak, and slightly higher for white oak. Spring values were higher than those for fall, for all species. CaO plus MgO determinations on a dry-matter basis were highest for linden, and lowest for red oak. Maple and hickory values were higher than those for white oak. Determinations on an ash weight basis did not follow the same trend, but indicated relatively greater leaching of both organic and mineral materials from linden leaves between fall and spring collections than from the other species.

Maximum temperatures of the air and

1. a. Chairman of Committee, J. M. Aikman, Professor, Dept. of Botany, Agricultural Experiment Station.

b. Doctoral Thesis No. 1102. Submitted August 18, 1950.

2. a. M. S., *ibid*; 1948.

b. Fellow, Dept. of Botany.

soil were significantly higher in open woods compared to closed stands, and were the highest on south aspects. Soil temperatures exceeded air temperatures under the latter conditions. Beneath closed canopies, soil temperatures were much lower, 10 to 15 degrees, than air temperatures regardless of slope or aspect. Soil temperature differences between 1 and 6 inches under open woods were greater than between 1 and 15 inches under closed stands and litter covers. As the season became warmer, these differences under open woods increased, but stayed nearly the same under closed stands.

Evaporation rates from Livingston atmometers were consistently lower under closed stands than in open woods, and were lowest under conditions which combined the effects of dense canopies and slope protection. Average accumulative evaporation losses were more than twice as great in open woods as for most mesic sites. Wind movement was more unrestricted in open woods due to thin stands and lack of shrub understories. Vapor pressure deficits were greater in these sites, indicating drier atmospheric conditions and steeper moisture gradients between transpiring surfaces of the leaves and the surrounding air. The ameliorative effects of dense canopies upon evaporation stress were less marked under conditions of low vapor pressure deficits, brought about during periods of cool temperatures and high humidities.

In open woods, moisture of the surface soil, 0- to 6-inch level, fell below wilting during July and August, but in closed stands this did not occur. However, in three forest profiles in steep well-drained positions soil moisture did fall below wilting in the subsoil. Soil moisture content in the upper 6 inches showed the greatest decrease with time, and the most variation among sites. Under open woods and sod cover, moisture depletion in the surface zone was the most intense, indicating high evapo-transpiration losses. Under closed stands with litter cover, average soil moisture was high in the surface and in the subsoils, and lower in the intermediate zones. Under open woods types, moisture was lower in the surface, and increased with depth. Moisture in the subsoils of closed stands and open woods did not vary greatly.

Rate of snow removal on south slopes exceeded that on north slopes under comparable stand densities. On areas of similar topography and aspect, density of the vegetation, including shrub and tree reproduction, was an influential factor in depth of snow accumulation and time of disappearance.

Increased aeration porosity and decreased volume weight of surface horizons indicated a more favorable physical condition in soil profiles under closed stands and litter cover. Surface soils on steep, broken slopes, under closed stands, had lower aeration porosities and greater volume weights compared to soils on less severe topography under comparable stands. Below the surface and subsurface horizons, aeration porosities and volume weights were not notably different between profiles under closed stands and litter floors, and those under open woods and grass or weed covers.

Total nitrogen and organic carbon percentages were highest in the surface soils of all profiles, the greatest values occurring under closed stands in the most favorable topographic positions. On severe slopes, under closed-forest, nitrogen and carbon values for the surface horizon were in some cases lower than for open-woods sites under grass cover. Grass was considered a factor in increasing the depth of maximum surface accumulation. Surface horizons were also deepened by cultivation compared to undisturbed forest horizons on similar topography and soil; however, carbon and nitrogen percentages were greatly reduced in the former. Comparing only zones of maximum surface accumulation in the undisturbed forest profiles, the highest average nitrogen percentages were for planosol soils, and the lowest for broken-land types. Beneath the zone of surface accumulation, no notable differences in carbon and nitrogen were shown among any or all profiles.

The C/N ratios diminished with depth in most profiles; in others the ratios were variable although diminishing trends were indicated. Ratios were not correlative with composition of the forest vegetation and ground cover.

The proximity of calcareous parent material to the surface was a dominant factor in soil reaction.

RANGE-ENERGY STUDIES OF FISSION FRAGMENTS¹

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Because of the distribution in the mass and initial effective charge of fission fragments, accurate measurements of their energies by electrostatic or magnetic deflection are not feasible. Instead, energy measurements are usually made by determining the number of ion pairs formed as fission fragments are stopped in a gas. In this investigation, a mathematical comparison of the known distributions of fission fragment mass and ionization (number of ion pairs formed) provides information on the conversion factor w between energy and ionization. This information allows an energy interpretation of the experimental range-ionization data obtained in this investigation by the electron collection method.

Information on the energy/ionization ratio w is obtained from a comparison of the distributions in ionization and the energy causing this ionization. The former distribution is accurately known, but the latter must be indirectly determined from the known mass distribution. Due to momenta considerations, the distribution in E_L/E_H is essentially the distribution in m_H/m_L , where L and H designate light and heavy fragments and m and E are the mass and initial kinetic energy of a fission fragment, respectively. Because of the dispersion arising from instrumental errors and neutron recoil, the initial energy differs from the energy causing ionization. Such a dispersion is applied to the E_L/E_H distribution to obtain the ratio distribution of the energy which causes ionization. This is compared with the ionization ratio distribution to find the variation of w_L/w_H with fission asymmetry.

The ratio w_L/w_H is found to vary slightly, becoming progressively smaller for greater fission asymmetry. For symmetrical fission an assumed unity value for w_L/w_H is used to evaluate the energy

dispersion. For the most probable fission asymmetry w_L/w_H is found to be about 0.96. Since only relative values of energy are available, the results are limited to relative values of w .

The results of this investigation of w are applied to a simplified energy loss theory in which most of the fission fragment energy is lost with a constant energy/ionization ratio but, due to nuclear collisions, the remaining energy loss does not appear as ionization. When the results for the most probable fission asymmetry are applied, the unobserved energy is approximately 1.9 Mev for the light fragment and 3.4 Mev for the heavy fragment. If these rather small unobserved energies are neglected, it appears that fission fragment ionization data are a true representation of energy data.

Range-ionization data were obtained for fission fragments stopped in argon, helium, and nitrogen. Here, the electron collection method was used to observe fragments from a natural uranium film bombarded by neutrons from a Po-Be source. The ionization chamber voltage was adjusted to give voltage pulses of about 10-microsecond duration. These pulses were electronically amplified and differentiated. Oscilloscope photographs of the differentiated waveforms were analyzed for range-ionization data. In addition, a "back-to-back" double-ionization chamber was used with a dual-beam oscilloscope and a duplication of the electronic equipment to observe simultaneously the range-ionization waveforms for the fragments from a fission pair.

About 15 photographs for each stopping gas were analyzed. For each gas no difference could be detected between the normalized range-ionization curves for heavy and light fragments. The normalized range-ionization curves for helium and nitrogen were the same and nearly quadratic in form. A different curve, more linear near zero range, was found when argon was used. The poorer neutron geometry of the double chamber experiment resulted in a lower fission rate and fewer data, which, due to their poor statistics, provided no unknown information on the properties of fragments.

1 a. Chairman of Committee, Glenn H. Miller, Assistant Professor, Dept. of Physics, Institute for Atomic Research.

b. Doctoral Thesis No. 1078. Submitted July 5, 1950.

2 a. B. S., Case Institute of Technology, Cleveland, Ohio, 1942.

b. Junior Physicist, Institute for Atomic Research.

To a large measure, the interdependent effects of recombination of ion pairs and of electron diffusion determine the quality of the range-ionization data from electron collection. Recombination in the dense column of ionization along a fragment path is large unless the agitation velocity of the free electrons in the gas causes a rapid separation by diffusion. Because of recombination the ionization signal, as compared with noise, was undesirably low when nitrogen was used; it was prohibitively low when carbon dioxide or hydrogen were used. By using different gas

pressures, range-ionization data were obtained for different conditions or range vs. ion density. Although limited in its scope, this experiment revealed no distortion due to the dependence of recombination on ion density.

Although electron diffusion reduces recombination, it distorts the range-ionization data by dispersing the electron configuration during collection. The diffusion error was found to be negligible for nitrogen, but not for argon. Neither recombination nor diffusion seemed objectionable when helium was used.

EVIDENCES OF THE IMPORTANCE OF PANTOTHENIC ACID DURING REPRODUCTION IN RATS¹

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Interest in the optimum intake of pantothenic acid for satisfactory reproduction for rats has evolved from earlier work in this laboratory which suggested a possible relationship between pantothenic acid deficiency and a pregnancy disorder in rats resembling toxemia. It had been noted in former studies that female rats ingesting an experimental ration which provided approximately 130 micrograms of pantothenic acid per day developed the pregnancy disorder shortly before parturition. Hepatic stores of such animals were considerably reduced in pantothenic acid at term.

Quantitative needs for this vitamin have been investigated by several procedures. In all cases the animals have been receiving the customary stock ration which has been known to support normal reproduction for many generations. The deposition of pantothenic acid in fetal and placental tissues has been measured during prenatal development. The quantity of vitamin excreted in the urine of rats throughout the pregnancy period has been determined in order to detect possible changes in vitamin needs as pregnancy progressed. The influence of adding calcium pantothenate to the stock ration

has been studied by analyses of the pantothenic acid content of the tissues of the female and her young. Also the effect of pantothenic acid withdrawal upon reproduction has been determined by incorporating an analog, omega-methyl-pantothenic acid into the stock ration.

Assays of fetal tissues of rats sacrificed at thirteen intervals during the gestation period revealed that 95 per cent of the pantothenic acid present in newborn rats was acquired after the sixteenth day of gestation. The maximum daily increment in total stores of the vitamin per litter averaged 650 micrograms. This maximum need occurred on the twenty-first day of pregnancy. The amount of pantothenic acid present in a single litter of newborn rats was equal to that found in the entire body of the adult female. The pregnant animals, having access to approximately 600 micrograms of pantothenic acid per day from the stock ration showed no measurable storage or depletion of their liver or carcass tissues during pregnancy.

Urinary excretion of pantothenic acid by adult female rats accounted for approximately one-third of the dietary intake of the vitamin prior to and during the first sixteen days of pregnancy. A marked change in urinary excretion of the vitamin was noted toward the end of the gestation period. At this time the surplus vitamin decreased to very small amounts. This altered excretion of pantothenic acid, however, was not sufficient to account for the rapid transfer of pantothenic acid to fetal tissue unless more efficient utilization of dietary pantothenic

- 1 a. Chairman of Committee, Gladys Everson, Professor, Dept. of Foods and Nutrition, Agricultural Experiment Station.
b. Doctoral Thesis No. 1096. Submitted July 15, 1950.
- 2 a. B. S., Louisiana Polytechnic Institute, Ruston, La. 1938.
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acid occurred during the latter portion of pregnancy.

The rapid deposition of pantothenic acid in fetal tissues and the decreased excretion of surplus vitamin during the last days of pregnancy suggest that the pregnant rat needs approximately 650 micrograms of extra pantothenic acid during the latter portion of the gestation period.

A question as to the value of the relatively high concentration of pantothenic acid in young rats was raised following the results of supplementing the stock diet with calcium pantothenate. The concentration of vitamin in the young was nearly doubled when 500 micrograms of calcium pantothenate was added daily throughout pregnancy. Addition of the salt of pantothenic acid on the sixteenth day of pregnancy or from the time of mating did not prevent the decline in urinary excretion of this factor just prior to parturition. If the amount of the vitamin transferred to the developing fetuses reflected the intake of the female in this case, the same might be true when the unsupplemented stock ration was fed. In light of the work of others concerning the rapid depletion of young animals, their inability to survive without added pantothenic acid and their unusual needs for early growth, it is believed that the concentrations present in the young of stock females are desirable. Possibly there is some advantage to the higher stores.

Determinations of both free and bound pantothenic acid in maternal hepatic tissue revealed that only 2 or 3 per cent

of the total pantothenic acid was present in the uncombined state. In contrast, approximately 80 per cent of the vitamin in the newborn was found to occur as free pantothenic acid. When extra calcium pantothenate was included in the stock ration the percentage of bound pantothenic acid present in the young increased somewhat.

The relatively high concentration of pantothenic acid in the newborn together with the greater portion of uncombined vitamin allows speculation that this factor may have an important role in the formation of new tissue beyond that of coenzyme A. Possibly the pantothenic acid designated as free may actually be combined in some manner which permits utilization by lactic acid bacteria. Possibly the conversion of free pantothenic acid to coenzyme A is slow in the newborn animal. Additional studies are needed to answer these questions and to also determine the correlation between the concentration of pantothenic acid present in newborn rats and their survival, growth, and general well being.

Attempts to develop "toxemia of pregnancy" by feeding omega-methylpantothenic acid were unsuccessful. Upper levels of the inhibitor caused complete resorption of the litters early in the pregnancy period. When .075 or .15 per cent of the diet was fed as the analog some defective litters were carried to term. Many of such young were in varying stages of resorption although a few animals showed essentially normal activity.

ORGANIZATION AND MANAGEMENT OF AN EXPERIMENTAL DIETARY PROGRAM AT GLENWOOD STATE SCHOOL. NUTRITIONAL ADEQUACY OF DIETS AND ASSOCIATED PHYSICAL GROWTH¹

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An experimental dietary program was conducted in connection with a dental

project at Glenwood State School, a school for the mentally deficient, at Glenwood, Iowa. The dietary program consisted of two regimens of six months each, one with no refined sugar and the other including refined sugar. It was under the combined direction of Iowa State College and the State University of Iowa.

The present investigation was concerned with the organization and management of the experimental dietary program; nutritional adequacy of the dietary regimens

- 1 a. Chairmen of Committee, Grace M. Augustine, Professor and Head, Dept. of Institution Management, and Ercel Eppright, Professor and Head, Dept. of Foods and Nutrition.
- b. Doctoral Thesis No. 1140. Submitted December 14, 1950.
- 2 a. B. S., College of Medical Evangelists, Los Angeles, California, 1933
- b. M. S., Oregon State College, Corvallis, Oregon, 1940.
- c. Associate, Agricultural Experiment Station.

and of anthropometric measurements of two groups of Glenwood girls on the controlled and the institution diets.

ORGANIZATION AND MANAGEMENT

The controlled dietary program was planned with cognizance of the fundamental principles of organization and management. There were group meetings and conferences with the superintendent and members of the staff and personnel of the institution. It was essential to organize and manage the program so that it would function satisfactorily within the institution.

A research associate, the author, one assistant research associate, one cook, and three inmate helpers were the project personnel in residence. The research associates planned and directed dietary project procedures, trained project personnel, standardized recipes and portions, planned menus, supervised the preparation and service of the experimental diets, calculated nutritive values of recipes and daily diets, maintained cost records, kept meal and other records of the individual participants, secured anthropometric measurements, and helped the participants to adjust to the conduct of the study.

The participants were 64 inmate girls ranging in age from 12 to 20 years. In some phases of the study other inmate girls of similar age served as controls. Strict regimentation of all children was maintained by the institution; this facilitated the conduct of the controlled dietary program.

A project kitchen was equipped in order to maintain adequate control, and all food for the controlled diets, except bread, was prepared there. In planning adequate menus it was necessary to follow closely the institution menu using available supplies. Supplements to the institution diet were purchased with project funds or donated.

The source and content of carbohydrate was the principle difference in the diets for the two periods. During regimen I there was no refined sugar; during regimen II approximately 110 grams were included per day. There was a planned divergence in the polysaccharide content of the diet. The size of the bread slice was reduced in period II, and additional sugar was substituted for the omitted starch.

All food was carefully weighed or measured in the preparation of the controlled diets. Devising and standardizing recipes was a major problem, particularly during period I. Acceptable sugarless recipes were formulated for pie filling, puddings,

and cookies. An ice cream formula without sugar using dried eggs and non-fat dry milk solids was developed by the Iowa State College Dairy Industry. Acceptable recipes for main dishes were devised to provide adequate protein.

Weighed or measured portions were served on compartment trays. Records were kept of each participant's food consumption and plate waste. A large per cent of the girls consumed the diet as served with no additions and no waste. During regimen I, 52 per cent of the girls consumed the diet as served, 46 per cent took additional food, and 3 per cent had plate waste; during regimen II, the corresponding per cents were 63, 33, and 4.

Originally second servings of available menu items were allowed; after three weeks additional food was restricted to bread. The aggregate range of additional bread per girl was from one to 973 slices during period I, and from none to 1,258 during period II. No explanation was found for times of greatest bread consumption. The caloric value of the day's diet was apparently not a determinant.

Plate waste on the basis of group averages was usually less than 10 grams per individual per meal. The greatest number had plate waste at breakfast. Only five girls had plate waste more than 50 times in the 552 or 543 meals of period I and II respectively.

The eating patterns of the children were with one exception conventional; the participants frequently finished the meal with bread. They were unusually fond of bread. Sandwiches were very popular and were made at the table with almost any menu item as filling, such as ice cream, mashed potato, pie filling, and macaroni. Greens such as spinach or Swiss chard and raw foods were well accepted. Reconstituted dry milk came to be accepted as well as fresh milk. Some food habits and preferences of the participants were similar to those observed in other studies. For example, they preferred lukewarm foods, and disliked dry meals and fat on meat. While they were dissatisfied with monotony and liked new dishes, they tended to prefer familiar foods.

The per capita labor hours per meal were .1706 hour or 10.24 minutes. The per capita labor costs per meal were \$0.0475 during period I and \$0.0516 during period II. Dishwashing and other work done by regular institution workers and low wages paid inmate helpers decreased project labor hours and costs.

The actual and evaluated per capita meal costs of the controlled diet were

calculated. The evaluated cost included actual cost plus estimated value of donated foods. The average per capita meal costs of the controlled diet as served were as follows: During period I for breakfast, dinner, supper, and the total day, \$0.090, \$0.175, \$0.115, and \$0.380 actual cost, and \$0.125, \$0.179, \$0.116, and \$0.420 evaluated, respectively; during period II the corresponding costs were, \$0.098, \$0.162, \$0.114 and \$0.374 actual cost and \$0.114, \$0.171, \$0.121 and \$0.406 evaluated cost, respectively.

NUTRITIONAL ADEQUACY OF DIET

The experimental dietaries were planned to meet weighted average allowances based on recommendations by the National Research Council for girls in the 10 to 12, 13 to 15, and 16 to 20 age groups. Weighted averages were used since it was desired to give all participants the same quantities of specific foods.

The nutritive content of the diet was calculated on a meal basis for each day during the two dietary regimens. The nutritive values of all recipes were determined. Nutritive values of food for each individual were calculated first on the basis of menu served; then, for additional foods taken as seconds.

The average caloric values of the menus served, 2,186 for period I and 2,317 for period II, were somewhat below the average allowance for the group. All other nutrients met or exceeded the average allowances except iron which was slightly below during both periods, vitamin D during the first six weeks of regimen I, and niacin which was very slightly below during regimen I. Although caloric values were below the weighted average allowance, a majority of the subjects gained weight during both regimens and lost weight during the six months following

the discontinuance of the project.

The natural sugar content of the diet was 40 per cent of the total carbohydrate during period I; the natural sugar content was 23 per cent and the refined, 32 per cent during period II. The sugar content of the diet during regimen II was 24 per cent higher than during regimen I.

ANTHROPOMETRIC MEASUREMENTS

Using standard methods of procedure, measurements were taken six times during twelve to fifteen months of the study. They were obtained on the 64 participants and a group of girls of similar age on the institution diet. Body size of the girls was compared with averages obtained for non-institution low and high socioeconomic groups. The girls at Glenwood tended to be below the average in height and hip width and above the average in weight, chest circumference, and calf girth.

Comparing the rate of growth of the participants with that of the control group over a one-year period, no difference was observed for height or hip width. The participants, however, showed a significant weight gain, and there was a similar increase for calf girth, although not statistically dependable.

When gains in weight of the participants in five-month periods in each regimen were compared, there was no statistically significant difference between the gains for the periods.

The over-all period of the experimental program herein reported extended from September, 1947, to June, 1949. State institutions such as Glenwood State School, because of continuous residence and regimentation of inmates, provide excellent opportunities for experimental dietary studies. Recommended procedures for setting up an experimental dietary program similar to the present investigation are given.

PLASTICS PREPARED BY ION CATALYZED POLYMERIZATION OF FURFURAL¹

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Department of Chemical Engineering

The ready availability and low price of furfural, which is obtainable from annually renewable raw materials, and the

ease of polymerization of this material by ionic catalysts without the use of heat or pressure, suggested its use in the manufacture of low-cost casting plastics. It had previously been shown that the incorporation of furfural resulted in a material having satisfactory strength and appearance, but the material was unsuited for commercial applications because the mineral acids used as condensing agents con-

- 1 a. Chairman of Committee, O. R. Sweeney, Professor, Dept. of Chemical Engineering, Engineering Experiment Station.
b. Doctoral Thesis No. 1085. Submitted July 13, 1950.
- 2 a. B. S., Purdue University, Lafayette, Indiana, 1941.
b. Cooperator, Engineering Experiment Station.

tinued to diffuse to the surface of molded articles over long periods of time.

In this study, the effects of a large number of additive compounds other than furfural were investigated. It was found that results obtained by the incorporation of a pair of additives were superior to those obtained by any one additive. One additive from the pair producing superior results was a form of lignin; the other was any one of a number of compounds falling into two general classes. The first class was made up of secondary aromatic amines; those compounds from this class which were found to be more effective were furfural, diphenyl-p-phenylenediamine, diphenylamine, and phenyl-beta-naphthylamine. The second class was made up of furan derivatives whose substituent groups had a relative electronegativity less than that of the aldehyde group of furfural. Compounds from this class which were found to be more effective were furfural, methylfuran, and furfural-

urea. The furfuralurea was prepared *in situ*.

It was found that the use of p-toluenesulfonic acid as a condensing agent resulted in a plastic which did not give the problems of acid diffusion which were encountered when mineral acids were used. The use of bromine also was a complete solution to the problem of acid diffusion, but the resulting product was limited somewhat in its applicability by a lower strength.

The plastic resulting from the condensation with p-toluenesulfonic acid of the casting syrups described has a beautiful, glossy black appearance, remarkable flame resistance, and good resistance to chemical reagents. It can be fabricated without expensive molding equipment, and is comparable in cost to the cheapest casting resins on the market today. This plastic should find use wherever an opaque, infusible, and insoluble material is suitable.

PROPERTIES OF IMMUNE SERA IN TRYPANOSOMA LEWISI INFECTION¹

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A study was made of the interrelationship in rats' blood between sodium salicylate treatment and ablasic activity against *Trypanosoma lewisi*. Results are reported on experiments concerning (1) sodium salicylate and ablasic plasma, (2) proteins and immune serum, (3) tryptophan and salicylate activity, (4) pantothenic acid and ablasic serum, and (5) blood glucose levels and ablasic blood. Where chemical determinations were made, they were made on four groups of rats. These were (1) rats with *T. lewisi* plus sodium salicylate treatment, (2) rats with *T. lewisi* only, (3) rats with sodium salicylate only, and (4) rats that were normal.

The infected rats used were male, *Bartonsella*-free, Wistar A rats with Becker's strain of *T. lewisi*. Salicylate treatment consisted of 45 mgm. of sodium salicylate

per 100 gm. weight of rat daily, by gavage. Passive immunity tests were carried out in susceptible rats by injecting the plasma to be tested intraperitoneally and following it with intravenous injection of dividing trypanosomes. Blood smears were made daily to see whether reproduction was inhibited. Rate of reproduction was estimated by determining the percentage of division forms. Trypanosome numbers were counted by the standard hemocytometer methods.

In the first group of experiments an attempt was made to see whether sodium salicylate caused the prolongment of the reproductive phase in *T. lewisi* infection by forming a complex with the anti-reproductive antibody, ablastin. Dilution of plasma from salicylate treated and infected rats by injection into susceptible rats did not cause a separation of such a possible complex. When immune serum was treated with the equivalent of 5 gm. sodium salicylate per liter for four hours *in vitro*, there was no alteration in the ablasic activity of the immune serum. Dialysis too, brought about no separation of a possible salicylate-antibody complex.

- 1 a. Chairman of Committee, Elery R. Becker, Professor, Dept. of Zoology and Entomology, Industrial Science Research Institute.
b. Doctoral Thesis No. 1080. Submitted July 11, 1950.
- 2 a. B. A., University of Manitoba, Winnipeg, Manitoba, 1939.
b. Associate, Industrial Science Research Institute.

From this evidence it was concluded that salicylate acted in a manner other than by combining with ablastin.

Earlier work by Becker and Lysenko³ indicated that ablastin could be broken down in recovered rats by administration of sodium salicylate, because reinfections with reproduction were possible.

In the next group of experiments serum protein levels were determined on the four groups of rats mentioned earlier. Protein levels in serum from *T. lewisi*-only rats were higher than in the other three groups.⁴ This suggested that salicylate acted by preventing the formation of ablastin. The administration of additional normal plasma protein had no effect on relieving the salicylate inhibition of ablastin formation. The feeding of tryptophan by gavage indicated that salicylate prevented the formation of ablastin other than by competitive replacement of anthranilic acid in the synthesis of the tryptophan molecule.

Electrophoretic studies on samples of pooled sera showed that the increase in the protein levels in the *T. lewisi*-only rats was due to an increase in the albumin and gamma-globulin fractions. The gamma-globulin fraction in this group of rats was 2 and 3.6 times greater than in the *T. lewisi* plus salicylate group. This suggested further, that sodium salicylate prevented the formation of ablastin. The evidence supported Taliaferro's⁴ idea that ablastin is formed in rats with *T. lewisi*, that it was a protein, and that it was in the euglobulin fraction of serum. Indirect evidence from these experiments would further limit the location of ablastin to the gamma-globulin fraction. The electrophoretic analyses were done by Mr. M. R. Dieckmann, in the laboratory of Dr. J. F. Foster, Iowa State College.

Pantothenic acid assays were made on the four groups of rats mentioned earlier. The results showed that there was no difference in the means of the four groups. This indicated pantothenate is involved in ablastic activity in a manner other than by being a part of the actual antibody. It may be of course, that the methods of assay were not sensitive enough to show a possible difference, or that the panto-

thenate was so bound to the antibody that it was not released.

Blood glucose determinations were made on the four groups of rats mentioned before in an effort to see whether there was any relation among glucose levels, trypanosome numbers, and the rate of reproduction of the parasites. Sugar determinations were made on tail blood on 0, 3, 5, 7, and 10th day of the infection. The results indicated that neither sodium salicylate nor *T. lewisi* infection alone affected the blood glucose levels of the host. Rats with both sodium salicylate treatment and *T. lewisi* infection showed a significant increase in blood sugar levels from 0 to the 10th day. Sugar levels on the 10th day in the *T. lewisi* plus sodium salicylate rats were found to be significantly higher than those in the other three groups of rats examined.

This evidence suggested two possibilities with respect to high glucose levels and prolongment of reproduction in the *T. lewisi* plus salicylate rats. Either the high glucose levels caused a continuation of the reproductive phase by providing excess carbohydrate, or the higher levels of blood glucose in the host were caused by a combined stimulation by the trypanosomes and salicylate treatment on the mobilization of increased blood sugar.

In view of the results in the experiments on proteins and immune sera, the latter possibility is probably nearer the truth. Thus the prolongment of the reproductive phase of *T. lewisi* in the rat as described by Becker and Gallagher⁵ due to sodium salicylate treatment, resulted from interference in the formation of ablastin.

The investigation was supported, in part, by a grant from the Industrial Science Research Institute of Iowa State College, Project 40.

3 Becker, E. R. and Lysenko, M. G. Reinfection with *Trypanosoma lewisi* and recurrence of reproduction in recovered and near-recovered rats. Iowa State College Jour. Sci. 22: 239-55. 1948.

4 Taliaferro, W. H. Trypanocidal and reproduction inhibiting antibodies to *Trypanosoma lewisi* in rats and rabbits. Amer. Jour. Hyg. 16: 32-84. 1932.

5 Becker, E. R. and Gallagher, P. L. Prolongment of the reproductive phase of *Trypanosoma lewisi* by the administration of sodium salicylate. Iowa State Coll. Jour. Sci. 21:351-62. 1947.

RELATIVISTIC EFFECTS IN NUCLEON- NUCLEON SCATTERING ¹

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Department of Physics

A large number of experimental and theoretical papers dealing with nucleon-nucleon scattering at energies of 90 Mev and above have appeared in the last few years. The theoretical papers have generally used the Schrödinger equation with a potential which is chosen to give the best fit to the experimental data. In particular, the experiments indicate that there is symmetry in the differential cross section about 90° in the center of mass system for neutron-proton scattering. This suggests a potential which acts only in even states, i.e., states in which the eigenvalue L of the orbital angular momentum is even, since the contribution of these terms to the cross section is symmetric about 90° . With this type of potential, the experimental data can be fit quite well, except that the total cross section is consistently too high by 5-10 per cent. If the concept of a potential is to be used at these high energies, the relativistic terms should be such that they decrease the total cross section to within the range of experimental error.

The purpose of the present work was to investigate the relativistic corrections that must be added to the cross section. The nucleons were treated as Dirac particles, and the Dirac equation for the two-nucleon system with an interaction potential was used. At the outset there is the difficulty that the only potential function which is strictly relativistically invariant has the δ -function as its radial dependence, i.e., the interaction takes place at a point. Since we wish to use a potential function with a finite range, it was necessary to add to the Hamiltonian a term which added nothing to the potential in the first approximation, but which made the expectation value of the potential invariant to the second order in v/c under a Lorentz transformation.

Aside from the radial dependence, the part of the potential which depends on the spin can be chosen in five ways, each of which leaves the Dirac equation invariant under a Lorentz transformation. A separation of the wave equation into four equations was made by breaking the wave function up into large and small components. The equation for the large component was found, keeping only terms of order $(v/c)^2$. There were no terms of order v/c , the zero order approximation being, of course, just the Schrödinger equation. The potential was chosen in such a way that the zero order term gave no contribution in odd states. From the five possible forms above, there were four ways in which they could be combined to give the desired potential.

With these potentials, the wave function for the large component was separated into partial waves. The Hamiltonian was found to commute with the square of the total angular momentum J^2 , the square of the total spin S^2 , the parity $(-1)^L$, and the z -component of the total angular momentum J_z . Eigen-functions of J^2 , L^2 , S^2 , and J_z were used, and the resulting equations for the radial components coupled states of equal parity. There was, however, no mixing of states of different total spin. For a given value of J , there were four differential equations, arising from the one singlet and three triplet spin states, two of which were coupled and the other two uncoupled.

In order to find the cross section, it is necessary to find the phase shifts for each value of J . There are a number of ways in which this may be done, but the one that was chosen was the variational approach. The problem for the Hamiltonian that was used is similar to that for tensor forces, and the analysis used in finding the variational principle for the phase shifts was much like that for tensor forces. An expression for the phase shift was found which was invariant to the second order for a first order change in the radial function. For the coupled equations, the expression involves both radial functions, and the phase shifts are found from the two solutions of a quadratic equation.

1 a. Chairman of Committee, J. F. Carlson, Professor, Dept. of Physics, Industrial Science Research Institute, Institute for Atomic Research.

b. Doctoral Thesis No. 1109. Submitted August 22, 1950.

2 a. B. S., Iowa State College, Ames, Iowa, 1946.
M. S., *ibid.*, 1947.

An application of the theory was made to the problem of neutron-proton scattering at 100 Mev. A square well potential was used, with a singlet range of 2.8×10^{-13} cm. and well depth of 11.6 Mev, and a triplet range of 1.5×10^{-13} cm. and a well depth of 59.1 Mev. It was found that the correction to the total cross section from the odd states was of a higher order than for the even states, so that the symmetry about 90° was unchanged. The total cross

section could be increased or decreased by 5-10 per cent depending on which of the four possible potentials was chosen. A decrease of this amount would bring the theoretical value into agreement with the experimental. Therefore, the relativistic corrections could account for the discrepancy and the representation of the interaction by means of a potential is still consistent with the data for energies up to 100 Mev.

CAUSES OF VARIATION IN 154-DAY WEIGHTS AMONG POLAND CHINA PIGS FROM MULTIPLE CROSSES OF INBRED LINES¹

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The objectives of this study were to measure the importance of certain sources of variation among the 154-day weights of the crosses produced from 12 inbred lines of swine, and to estimate how these lines will perform in future crosses. The lines were Poland Chinas developed and maintained by the Iowa Agricultural Experiment Station. The crosses studied were only those involving three or more lines. In all cases the sire was an inbred and the maternal grandsire was an inbred from another line. In most cases the maternal granddam was an inbred from a third line. Where the maternal granddams were crossline females, these were grouped together and considered as another and special "line." Thus each cross was considered as a three-way cross.

The differences among the genic values of the lines, season-place groups, litters within three-way cross, season-place subclasses, and pigs within litters were important causes of the variation in the 154-day weights of the 2,137 three-way-cross pigs in this study. The maternal effects of the lines and the interactions between the different effects were not statistically significant. The interactions considered were: the interaction between three-way crosses and season-place groups, the interaction between the sire lines and the separate dam lines or the single crosses

between them, and the inter-action between the lines used to produce the single cross females.

Variance components were estimated as: $\hat{\sigma}_g^2 = 27$, $\hat{\sigma}_r^2 = 228$, $\hat{\sigma}_w^2 = 450$, where the g 's ($\frac{1}{2}$ the genic values of the lines), r 's (litter effects within three-way cross season-place subclasses) and the effects (w) peculiar to individual pigs within litters are assumed to be independently distributed around mean = zero with

variance σ_g^2 , σ_r^2 , and σ_w^2 respectively. From this, it is estimated that .17 of the variation in foundation stock from which these lines were developed was due to differences in genic values of the animals, i.e., heritability in that population = .17.

The estimates of the g values of the lines were $\hat{g}_a = 1.8$, $\hat{g}_b = -3.8$, $\hat{g}_c = -8.3$, $\hat{g}_d = 1.3$, $\hat{g}_e = -3.7$, $\hat{g}_f = 4.4$, $\hat{g}_g = 10.3$, $\hat{g}_h = 12.1$, $\hat{g}_i = -2.9$, $\hat{g}_j = 5.4$, $\hat{g}_k = -5.5$, and $\hat{g}_l = -2.4$. \hat{g}_l represents the least squares estimate of the g value of line l , using μ , g , m (maternal effect of a line), d (interaction between the lines used to produce the single-cross females), and b (season-place effect) in the model. The $\hat{g}_l + 144.6$ (which is $\hat{\mu}$) is the average of the crosses which had a sire from line l , corrected for the estimated effects of the season-place groups and of the single cross females the sires were mated to.

The estimates of the g 's were affected only slightly by leaving m and d out of the model.

The way lines A, B, G, and S (only lines

1 a. Chairman of Committee, Jay L. Lush, Professor, Dept. of Animal Husbandry, Agricultural Experiment Station.

b. Doctoral Thesis No. 1176. Submitted June 8, 1951.

2 a. B. S., Agricultural and Mechanical College of Texas, College Station, Texas, 1947. M. S., Iowa State College, Ames, Iowa, 1948.

tested on farms) performed in the farm testing program corresponded closely with the estimates of their *g* values.

The correlation between the estimates of the *g* values of the lines and the average weight of the pigs in the inbred lines was above .6, but is based on only 10 degrees of freedom.

Estimates of how lines will perform in future single crosses or three-way crosses were made.

The large mean square among season-place groups, as compared to the mean square among litters within three-way-cross, season-place subclasses, indicates that comparisons among pigs should be on a within season-place group basis. In other words, the effects of season and place sometimes differ so importantly that they can often hide or confuse differences

among lines, if the pigs in the lines are produced in different seasons or places.

The estimates of different causes of variation among the crosses indicate that the best way to form inbred lines which will produce heavy linecross pigs at 154 days is to:

1. Start many lines, probably by breeding a boar to several of his sisters.
2. Cull a large percentage of the lines on the basis of the 154-day weight of the pigs produced in the first and second generations of inbreeding.
3. Select within lines.
4. Make as many of the comparisons as possible within season-place groups.
5. Test the more promising lines in crosses to determine the best cross combination.

INSECTICIDAL CONTROL OF THE PECAN NUT CASEBEARER¹

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Insecticidal control of the pecan nut casebearer was first attempted by U.S.D.A. workers about 1915. Results with lead arsenate were not entirely satisfactory in the humid southeastern states where it was investigated. By 1935, life history and control research indicated that economical control of the casebearer was possible with lead arsenate under the less humid conditions of Texas. Fixed nicotine showed promise as a control in the humid sections of the South. Lead arsenate and fixed nicotine became the recommended insecticides. The work reported herein was conducted in an effort to find more effective and economical insecticides for control of the casebearer. The experiments, extended over a period of three years and were conducted in the Colorado River bottom near Smithville, Texas.

Treatments were randomized and replicated using the Moore, Success and Money-maker varieties of pecans. The treatments consisted of lead arsenate, fixed nicotine, DDT, BHC, toxaphene, parathion and

combinations of lead arsenate with nicotine or BHC. DDT was also combined with nicotine sulfate, BHC, and sulfur.

The criteria used to determine the effectiveness of the insecticides in controlling the casebearer were: (1) weekly records of the percentage of nuts injured, (2) percentage of nuts lost per 100 clusters and (3) yields.

DDT and combinations of DDT with nicotine sulfate or BHC were the most effective insecticides used in 1947. DDT and parathion were equally effective in 1948 and 1949 and gave the best control of the casebearer. Mites and aphids are likely to become injurious to the foliage following applications of DDT or DDT combined with nicotine sulfate or BHC. Indications are that DDT with sulfur may prevent an increase in mite populations. Mites and aphids do not appear to be a problem when parathion is used.

Toxaphene ranked third in the list of materials tested for effectiveness in controlling the casebearer. No data are available on the effects of toxaphene on the ecological balance in a sprayed orchard.

Mites and aphids were not a problem when the nicotine were used alone. However, the nicotine were of little value in preventing build-up of mites and aphids when combined with DDT or lead arsenate. Nicotine sulfate combined with summer miscible oil and Blackleaf 155 gave

1 a. Chairman of Committee, H. M. Harris, Professor and Head, Dept. of Zoology and Entomology, Agricultural Experiment Station, Agricultural and Home Economics Extension Service, Industrial Science Research Institute.
b. Doctoral Thesis No. 1088. Submitted July 14, 1950.
2 a. B. S., Agricultural and Mechanical College of Texas, College Station, Texas, 1939. M. S., *ibid.*, 1942.

better control of the casebearer than lead arsenate in most cases. Generally, larger and better filled nuts were produced on trees sprayed with nicotine.

Two pounds of six per cent gamma BHC in 100 gallons of water was about as effective as lead arsenate, but the effectiveness was increased over that of lead arsenate when the application contained two pounds of 12 per cent gamma BHC per 100 gallons of water. Use of BHC may result in an increase of mites.

Lead arsenate alone was least effective in controlling the casebearer. Combina-

tions of lead arsenate with BHC or nicotine sulfate and summer miscible oil increased effectiveness but the increase was not sufficiently great to be superior to DDT or the DDT combinations. Aphid increase usually follows lead arsenate applications. The combinations of lead arsenate with BHC and nicotine sulfate plus summer miscible oil had little effect in preventing this increase.

In the experiments with the airplane applications of insecticides, no satisfactory control was obtained with ten per cent DDT dust or with DDT as a spray.

ZINC-1,10-PHENANTHROLINE COMPLEXES AND THEIR ANALYTICAL APPLICATION¹

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The use of ultraviolet spectrophotometry for quantitative inorganic analytical purposes has long remained unexploited. An extremely large number of complexes of metals have characteristic absorption properties in the visible portion of the spectrum and many colorimetric methods of analysis depend upon this fact. With the present availability of ultraviolet spectrophotometric equipment the characteristic absorption properties of many "colorless" metallic complexes in the ultraviolet region of the spectrum should as conveniently be capable of similar utilization.

With a view of extending the knowledge of "colorless" complexes with absorption in the ultraviolet region of the spectrum a study of the zinc-1,10-phenanthroline complexes was undertaken.

Experiments are cited which show that the optimum pH to be used in the study is 5 and that maximum absorption of the complex occurs at 292.5 mμ. Consequently these conditions are used throughout the succeeding portions of the work.

A time study of the stability of the complex was carried out. Results cited indicate that equilibrium is rapidly established and is maintained for at least 115 hours.

Studies made by means of the use of

Job's method of continuous variations, the mole ratio method, and a conductometric method present evidence that the ratio of 1,10-phenanthroline to zinc in the complex is 2:1. On the basis of further evidence however, it is finally concluded that there are in reality three complexes formed.

The molar absorptancy indexes and the instability constants of the three complexes are estimated by a method of successive approximations. The values obtained for these quantities are as follow: $a_1 = 10,000$, $a_2 = 18,500$, $a_3 = 28,500$ and $K_1 = 3.4 \times 10^{-7}$, $K_2 = 1 \times 10^{-13}$ and $K_3 = 9.17 \times 10^{-14}$ for the molar absorptancy indexes and instability constants of the 1:1, the 2:1 and the 3:1 complexes respectively.

An equation was developed involving these six quantities and the analytical concentration of the zinc(II) and 1,10-phenanthroline by means of which, it should be possible to calculate the absorptancy of any mixture of zinc(II) and 1,10-phenanthroline. Results obtained were only fair but were as good as similar calculation made using values given for the three instability constants in the literature by I. M. Kolthoff.

The molar absorptancy index of 1,10-phenanthroline was determined to have a value of 6,660. This value is also necessary in the calculations mentioned above.

A method for the determination of zinc(II) is outlined and the interference of various ions is shown. A statistical analysis of the data is carried out for the purpose of determining the best straight line through the data and to prove that the

¹ a. Chairman of Committee, Charles V. Banks, Associate Professor, Dept. of Chemistry, Institute for Atomic Research.
b. Doctoral Thesis No. 1173. Submitted June 7, 1951.

² a. B. S., Mt. Allison University, Sackville, N. B., 1939.
M. S., *ibid.*, 1941.

Beer-Lambert law is obeyed. Further analysis of the data provides a measure of the error to be expected in a determination, and permits estimation of whether a given ion interferes.

It was considered particularly desirable to be able to determine zinc as a contaminant in metallic zirconium but this can not be done accurately since zirconium(IV) forms a complex with the 1,10-phenanthroline. Iron(III) is reduced in solution to iron(II) which interferes and since iron is a very common contaminant the method has limited application. It appears, however, to have promise in the determination of zinc(II) in the presence of aluminum(III) provided that iron is absent.

Sodium-p-sulfobenzearsonic acid was prepared to be used as a masking reagent for zirconium(IV). This material has the property of keeping zirconium(IV) in solution at the pH used but has itself a high absorptancy which negates its use in this method. It is suggested that possibly a sulfonated alkyl arsonic acid might be useable. The spectra of the sodium p-sulfobenzearsonic acid and of n-propyl-arsonic acid are given.

In general, in the absence of ions which interfere with 1,10-phenanthroline such as iron, nickel(II), copper(II), and zirconium(IV), a precision of at least ± 10 ug. zinc(II) per 100 ml. of solution is to be expected.

RELATION OF TECHNICAL ASSISTANCE TO LEVELS OF LIVING IN UNDERDEVELOPED AREAS¹

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A problem of great interest today is that of raising the level of material well-being for two-thirds of the world's people. These people live in countries called economically backward or undeveloped. Their productivity and hence incomes are lower than necessary under modern production methods.

There has been a long history of attempts by various groups to alleviate misery among people in areas of poverty, but the widespread concern with economic development in underdeveloped countries was spot-lighted and emphasized more forcefully in President Truman's Point Four proposal than it ever had been before. The fourth point in his inaugural address did not recommend relief of the symptoms of poverty but proposed a sharing of technical information which would help backward areas to eliminate the source of the symptoms, viz., low productivity.

Technical assistance to other countries from United States Government agencies is not as new as the Point Four name. United States influence is felt in the World Bank and other United Nations organizations concerned with economic progress and related problems. The expansion of business firms abroad has, intentionally or otherwise, affected standards of living in countries where they operate. Governments at both the national and international level, private business and non-profit organizations for some time have served as carriers of modern techniques to areas characterized as economically backward. Both the interest in and the activity of this kind which recently has received so much publicity almost justifies our speaking of a "Point Four movement."

The Rockefeller Foundation in 1948 made an economic Survey of Crete to assess current conditions and to serve as a basis for self-help projects which would raise levels of well-being on the Island. This Survey is more than an isolated example of concern with the well-being of a relatively few people on a small Mediterranean Island. Rather, it is part of a larger pattern which is taking shape in the world today, a concern with the economically backward countries.

LEVELS OF LIVING IN CRETE*

The level of living portion of the Crete

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* Most of the information on Crete is based on data acquired from the Rockefeller Foundation Sample Survey of Crete. For that information the writer is indebted to the Foundation.

Survey was only a part of a much broader study of the Cretan economy. The following is a summary of findings concerning levels of living.

The Cretan family averages, roughly, four persons. Over four-fifths of the families live in rural communities.

Household production contributes an important part to the total income in many Cretan households, especially in the rural villages. Some goods and services are purchased with cash income which the family gets largely from the sale of farm products or from the sale of labor. In addition to what the family buys with this, much that is consumed is produced in the home for direct consumption. The most important real income produced directly by the household includes: services of the housewife and other family members; spinning, weaving and other crafts; slaughtering of animals for home use; food processing, canning, bottling and drying. Further sources of real income are the services from owned homes and such durable goods as the family has, plus certain community services like roads, schools, health facilities, etc.

Cretans, for the most part, live in white-washed stone houses with clay or tile roofs. There are approximately three rooms per dwelling, and nine square meters of floor space per person. The small number of rooms does not assure what United States standards would define as adequate privacy, but this is less serious at the moment than the need for repairs arising out of wartime destruction and neglected maintenance repairs.

Bread and olive oil are basic foods and extremely important in the Cretan dietary pattern. The rather small consumption of meat, dairy products and other animal protein foods is important in explaining the most serious nutritional deficiencies, viz., animal protein, calcium, riboflavin and vitamin A.

At the time of the Survey in 1948, 86 per cent of males and 60 per cent of the females over 8 years of age, living in cities, reported that they were able to read and write. In the rural areas the percentages were 81 and 58 per cent, respectively.

Cretan incomes are low. This fact is indicated by such factors as the high percentage of income spent on foods, the large percentage of working population engaged in agriculture and the small capital investment per farm in this predominantly agricultural economy.

The relationship of low incomes to low

productivity presents a long run problem, but along with this is the more immediate problem of adjustment and reconstruction arising out of war and occupation.

Though the over-all picture in Crete does not reveal such low levels of living as one finds in the countries which are most backward economically, much could be done to improve the material well-being of the Island families, especially as regards sanitation. This is encouraging because the Cretans can do much for themselves, and the problems are such that their partial solution, at least, is within the realm of possibility over a reasonable period of time. Where outside help may be most desirable is in the financing of some permanent improvements whose cost of maintenance would not be excessive for Cretan purses, particularly in community water supplies and sanitary facilities.

THE TOTAL NATURE OF A LEVEL OF LIVING

The Crete Survey, like most other studies which have been made as a preliminary to proposed development projects, was concerned largely with production and with the material, quantitatively measurable components of the level of living. Other aspects of the level of living must be considered, too. Failure to consider "other aspects" is one of the most serious weaknesses of the levels of living portion of the Crete Survey.

The level of living includes the whole pattern of living at a particular time. As such it includes not only measurable quantities of goods and services used or available for use, but is made up of other components which are not always quantitatively measurable.

Though we in the United States and other Western industrialized countries are much aware of the benefits of high productivity, increased output for some people may not in itself improve living conditions in the way some assistance proposals imply. Not only the size of the income but the use to which it is put deserves attention. Desirable as it is to eliminate the worst misery and disease in the world, the virtues of increased production must be viewed in proper perspective. This means that one must always regard income as a means to an end. Most especially is this true for those areas of the world where values are different, and where economic activity, in itself, may have a much lower subjective value than it has in our own society. What may be

appropriate means in a highly industrialized country may not be appropriate for an area whose ends are quite different.

If the way to greater material well-being is via increased productivity, how can modern methods in industry and agriculture best be adapted to the needs and wishes of the recipient country? The methods of achieving a particular end (higher incomes, e.g.) may vary. If more acceptable methods are employed, a successful project is more likely. A preliminary study of the whole pattern of living may provide some help in dealing with this kind of problem. Furthermore, such a study provides a base which later can be used in evaluating a program of economic development.

PRINCIPLES RELATING TO CULTURE CHANGE

Numerous studies of culture change have been made over the years. From these there have evolved some general principles that should be kept in mind during the planning and implementation of programs in the backward areas. The following are presented as examples.

1. The contribution of technical assistance is not enough. The success of projects in areas receiving technical and financial assistance will be closely related to the success with which necessary changes in agricultural and industrial production and distribution can be adapted to a cultural setting different from that of the contributing countries in which the techniques were developed.
2. Recommended changes will be likely to be more acceptable if they possess a similarity or relation to something already present and accepted in the pattern of living, or if the agencies of their proposed introduction is one with which the people already have a long established sympathy.
3. Balance in the expansion of consumption is even more important than balance in agricultural and industrial development. Within the family, the consuming unit, resources are used in acquiring a great variety of "things," tangible and intangible, all of which are inter-related. They are mutually interdependent, to a degree complementary to and substitutable for other items. There is something more here, however, than the complementarity and substitutability of goods. Increasing the consumption of certain foods, or the floor area of shelter or underclothing

per person, e.g., might conceivably necessitate changes which would not be considered worth the price. Leisure time or old methods of production which are socially pleasant may not be willingly surrendered, at least not immediately, nor without resistance. The specialist in a particular field must be aware of the demands on a family's resources, which are always limited. Recommendations for improving one item in the pattern of consumption must be made in light of the whole pattern.

4. Recommended changes must not be implemented too rapidly. A way of life which has come into being over the years has roots too deep to be choked by a seedling planted on the surface. Given time and care, the seedling of new ideas and methods may take root and find its place among the old and accepted.

CONCLUSIONS REGARDING CHANGES ACCOMPANYING DEVELOPMENT PROGRAMS IN BACKWARD AREAS

In some parts of the world the problem of introducing new techniques to underdeveloped areas will be more complex than that of taking another cultural pattern into account. For example, another kind of problem which has arisen in some countries stems from the fact that early activities of Western nations that were imperialistic and which exploited native labor and resources disregarded cultural values in the areas where they operated. As a result there was left a legacy of bitterness and hatred toward the West. The growth of nationalism in many of the economically backward areas make it possible for leaders in those countries to exploit that bitterness in uniting the people. Communist agitators, particularly, are quick to make the most of such a situation. In some cases they already have done so. That factor is of great importance to the United States. The proposed Point-Four programs to promote economic development in backward areas, are, after all, only a part of United States foreign policy to oppose the spread of communism.

It is relatively easy to find out whether a country's productivity is low and the majority of its people poor and plagued with preventable diseases. Some recommendations that would improve the situation also may be rather obvious. Greater efficiency in production on the one hand, and on the other hand more education, the use of elementary principles of sanitation,

and an increase in hospitals and medical personnel usually follow from studies of economically backward areas. In general, of greater difficulty than deciding *what* should be done is deciding *how* it should be done. The methods of bringing about "improvements" so that the latter will be most readily acceptable pose a very difficult problem.

Before any assistance program is begun in Crete or elsewhere there should be a survey of the culture and its dynamics, present changes and their probable di-

rection; also the economic, social and political organization of the area. This would be followed by an appraisal of the problems to be dealt with, and recommendations made in light of the culture in which the problems are to be met. Finally, at some subsequent period there should be a check of what changes have actually taken place in the pattern of life, and these changes related so far as possible to their causes, so that both deliberate policies and other causes of change may be critically evaluated.

PREPARATION AND BASIC CLEAVAGE OF SOME ARYLSILANES¹

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Although many studies have been reported on the relative ease of cleavage of organic radicals from silicon or metals by acidic or electrophilic reagents, relatively few similar studies have been made using basic or nucleophilic reagents. It was the purpose of this thesis to survey previous work in this field and to prepare and cleave various arylsilanes with basic reagents.

The following previously unreported silanes were prepared from triphenylchlorosilane and the corresponding organolithium reagent (the percentages refer to the yields obtained): *n*-propyltriphenylsilane (89 per cent), m. p. 84°; *n*-amyltriphenylsilane (41.2 per cent), m. p. 47°; *n*-hexyltriphenylsilane (99 per cent), m. p. 78°; triphenylbenzohydrylsilane (66 per cent), m. p. 159°; triphenyl-9-fluorenylsilane (70 per cent), m. p. 184°; triphenyl- α -phenylethylsilane (95 per cent), m. p. 147°; triphenyl-1-indenylsilane (12.3 per cent), m. p. 136°, and 1,1-bis-(triphenylsilyl)-indene (9.8 per cent), m. p. 206° (both from 1-indenyllithium); and triphenyl-*m*-trifluoromethylphenylsilane (72 per cent), m. p. 101°.

The following order was found for the decreasing ease of cleavage of R radicals from silanes of the type $(C_6H_5)_3SiR$ by an

ethanol-dioxane (1:1) reagent 0.73 *M* in potassium hydroxide and 1.90 *M* in water: phenylethynyl (10 min., 25°), 100 per cent; indenyl (10 min., 25°), 100 per cent; 9-fluorenyl (10 min., 25°), 100 per cent; benzohydryl (30 min., 60°), 90.7 per cent; benzyl (60 min., 60°), 24 per cent; *m*-trifluoromethylphenyl (5 hrs., 60°), 15 per cent; *p*-chlorophenyl (24 hrs., 85°), 73.6 per cent; β -naphthyl (24 hrs., 85°), 15 per cent; and (β -phenylethyl, methyl, *n*-hexyl), no cleavage within 24 hrs. at 85°. The above percentages were based on recovered silane and no cleavage of phenyl groups was detected in any case. The relative positions of the *p*-chlorophenyl, α -naphthyl, and phenyl groups correspond to those generally obtained in metal-metal interconversions [Gilman, Moore and Jones, *J. Am. Chem. Soc.*, 63, 2482 (1941)]. The series of decreasing acid strengths of the RH hydrocarbons corresponding to some of the above radicals [Conant and Wheland, *J. Am. Chem. Soc.*, 54, 1212 (1932); McEwen, *ibid.*, 58, 1124 (1936)] was found to be: (phenylacetylene, indene), fluorene, diphenylmethane. Toluene, benzene, and *n*-alkanes were predicted to be still weaker acids in this order. Thus there appears to be a definite correlation between the above cleavage series and the acid strength series. A probable mechanism to explain this relation was proposed which involves the formation of a pentavalent silane intermediate with the nucleophilic reagent, followed by a loss of the most electron-attracting radical. This radical would then immediately take a proton from the solvent.

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Treatment of methyltrichlorosilane with two equivalents of *p*-chlorophenylmagnesium bromide followed by hydrolysis gave 31 per cent of 1,3-dimethyl-1,1,3,3-tetrakis-(*p*-chlorophenyl)-disiloxane, m. p. 69°. The reaction of (trichloromethyl)-triphenylsilane with *n*-butyllithium and with phenyllithium gave triphenyl-*n*-butylsilane and tetraphenylsilane, respectively. Trimethyl-(triphenylmethyl)-silane, m. p. 173°, was prepared by treating trimethylchlorosilane with triphenylmethylsodium, with triphenylmethyl lithium, and with triphenylmethylmagnesium bromide, respectively. This silane was cleaved by potassium hydroxide in aqueous acetone to give 95 per cent triphenylmethane and trimethylsilanol but was not decomposed by hydrogen chloride in glacial acetic acid. The reaction between triphenylmethyl lithium and triphenylchlorosilane at 125° for 40 hours gave a complex mixture of products melting from 200° to 335°. Tri-*p*-tolylcarbinol was prepared in 78 per cent yield from *p*-tolyllithium and ethyl orthocarbonate. This carbinol was reduced to tri-*p*-tolylmethane, m. p. 67° by refluxing with 98 per cent formic acid. Treatment of the tri-*p*-tolylmethane with *n*-propyllithium gave 70 per cent tri-*p*-tolylmethyl lithium. The latter reagent did not react with triphenylchlorosilane in twenty-four hours at 120° to 140°. *p*-Bromophenyllithium and ethyl benzoate gave 39 per cent bis-(*p*-bromophenyl)-phenylcarbinol, m. p. 124°. This carbinol was converted in 90 per cent yield to bis-

(*p*-bromophenyl)-phenylmethane, m. p. 100°, by refluxing with 98 per cent formic acid. This latter carbinol was also treated with two equivalents of *n*-butyllithium followed by triphenylchlorosilane to yield 66 per cent bis-[*p*-(triphenylsilyl)-phenyl]-phenylcarbinol (71 per cent); m. p. 290°. This latter carbinol was converted to bis-[*p*-(triphenylsilyl)-phenyl]-phenylmethane (71 per cent), m. p. 315°, by treatment with hydrogen chloride in benzene followed by lithium aluminum hydride. This last compound was not the same as a product (m. p. 335°) obtained from the reaction of triphenylmethyl lithium and triphenylchlorosilane.

A method for the determination of silanols by titration with the Fischer reagent is given. The titration reaction can also be used as a preparative method for alkoxysilanes by using other alcohols besides methanol in the Fischer reagent. For example, a reagent containing *t*-butyl alcohol reacted with triphenylsilanol to give a 73 per cent yield of triphenyl-*t*-butoxysilane, m. p. 104°. This latter compound was also prepared in 23 per cent yield by refluxing triphenylchlorosilane with *t*-butyl alcohol and dimethylaniline.

Incidental to these studies, a number of arylsilanes was prepared which contain groups present in active insecticides and these were submitted to Dr. C. H. Richardson of the Department of Entomology, Iowa State College, for evaluation of their insecticidal activity.

CONSUMER'S CHOICE IN INSURANCE¹

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The problem of the consumer in deciding whether or not to buy a life insurance policy has been treated in terms of presenting information about the many varieties of insurance contracts so that the consumer could choose the type which was most suitable to his particular needs. The large number of variations in life

insurance policies is due to the practice of combining a savings program with the plan for risk protection. Many authorities advise that these two plans should be separated, since a decrease in income may cause the policy-holder to want to discontinue the savings program, but at the same time to continue buying risk protection. Only the problems in choosing risk protection are discussed here. The factors to be considered in planning a savings program are not presented.

Behavior problems may be treated in descriptive terms (what people do) or in normative terms (what is "rational" or advisable to do). Deciding on insurance is

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treated here as a normative behavior problem. That is, whether to accept or reject a policy covering either a fraction, or the total monetary value, of the insurable item is regarded in this paper as a problem in "rational" decision-making.

"Rational" choice is assumed to require among other characteristics, that the individual be able to state what mutually exclusive outcomes may result from each choice, and to order them transitively in terms of his preferences. (Transitivity means that if *A* is preferred to *B*, and *B* is preferred to *C*, then *A* must be preferred to *C*). The term "preference" is used in its wider meaning which includes the case of indifference. These orderings may be accomplished by associating with each outcome an entity called "utility" which is orderable, but not necessarily measurable.

The outcomes of decisions made depend on two types of factors, those under the individual's control (which choice is made) and those outside his control (the occurrence of various "external" events). The principles of choice-making are selected according to the "type of knowledge" about the occurrence of the external events. The "types of knowledge" are classified into three groups according to the extent of the subjective, *a priori* knowledge about the occurrence of the external events. By using subjective knowledge the outcomes are not defined by questions of fact, but by what the individual believes to be true. The three groups are:

Case I—Decisions in which the individual knows which event will occur.

Case II—Decisions in which the individual can state the likelihood (probability) of the occurrence of each of the external events.

Case III—Decisions in which the individual has no knowledge of the probabilities of the occurrence of the external events.

PRINCIPLES OF DECISION-MAKING AND REQUIREMENTS FOR SOLUTION

Case I. In Case I only one possible outcome corresponds to each choice, since it is known (subjectively) which external event will take place. The principle used to make the rational decision is that of utility maximization. Since insurance problems are commonly considered in terms of losses in the main part of this paper, the suggested variations of the principle of maximizing utility are used as principles of minimizing loss in utility. The rational choice is that followed by choosing the outcome with the highest

utility attached to it. It is not necessary that utility be measurable here; it is sufficient that it be orderable.

Case II. In Case II there are two possible outcomes corresponding to each choice. The outcome depends on which external event takes place, and the probability of each external event is known.

The principle used to make the rational decision is that of maximizing the "average" utility. (In what follows, whenever the term "average" is used, it should be interpreted as meaning a long-run average, i.e., the "mathematical expectation.")

To clarify the requirements for a solution, Case II is divided into two parts, Case II-A and Case II-B. Case II-A contains decisions in which there is one choice for which the outcomes, with respect to each external event considered, are both respectively greater than the outcomes from other choices. It has been shown in this paper that in Case II-A an ordering of the outcomes is sufficient to determine the rational decision.

Case II-B contains decisions in which there is no choice as specified in Case II-A. In Case II-B it has been shown that measurable utility is needed in order to determine which choice gives the maximum average utility. It has been shown by J. Marschak (1) that measurable utility is implied by certain axioms on "rational" behavior of individuals under risk.

Case III. In Case III, which typically includes decisions on buying insurance, there are two, alternative approaches to decision-making, the "utility" approach and the "regret" approach. The "utility" approach will be considered first.

THE "UTILITY" APPROACH

One possible criterion for choosing is described as follows: the individual indicates for each choice the "worst" outcome, or the one with the lowest (minimum) utility; he then decides on the choice in which the "worst" outcome is better than the "worst" outcome for any other choice (the maximum of the minimum outcomes). This is called maximizing the minimum utility.

Another possible criterion is this: assume some arbitrary probabilities for each of the external events, and compute the "average utility" as in Case II. Then behave in such a way that this average utility becomes the highest possible, even for the most "pessimistic" assumption with regard to the probabilities of the external events. This is called maximizing the minimum average utility.

It has been shown by Von Neumann and

Morgenstern (2) that in an important class of cases, these two criteria lead to the same solution for rational behavior. To describe this class of cases we need the concept of the "best" outcome for a given external event, i.e., the highest utility outcome. If the lowest of all the "best" outcomes (for the different external events) happens to equal the highest of all the "worst" outcomes (for the different choices), this highest, "worst" outcome (which is also the lowest of the "best") is called the "minimax." In a given situation the minimax may or may not exist. It is only when a minimax does not exist that the two criteria described (maximizing the minimum utility and maximizing the minimum average utility) lead to the same result. To clarify the requirements for a solution, Case III is divided into Case III-A, containing situations in each of which there is a minimax, and Case III-B, containing situations in each of which there is no minimax.

It has been shown in this paper that only orderable (not measurable) utility is needed when a minimax exists (Case III-A). Furthermore, when the "utility" approach is used it has been shown that all decisions on insurance have a minimax, hence they do not require measurable utility.

In Case III-B, in which there is no minimax, Von Neumann and Morgenstern (2) have shown that the two criteria described give different outcomes. The behavior which gives the maximum of the average utility minima is "randomized." That is, a device, such as a die, is used for choosing each time a decision is made so that the average (the mathematical expectation of each choice corresponds to its determined value. In order to determine the "optimum" values of the ratios between choices used on the randomizing device, the utilities of the outcomes must be given a numerical value. Since all decisions on insurance using the "utility" approach have been shown to fall into Case III-A, "randomized" behavior is not needed in these decisions.

THE "REGRET" APPROACH

If the principle of maximizing the minimum average utility is used, it neglects

the dissatisfaction arising out of having made the "wrong" choice in regard to the actual occurrence of events. If regret is considered to be important, the principle used is the minimizing of the maximum average regret.

The decisions using the regret principle can be classified into Case III-A and Case III-B, with the same requirements concerning measurability of utility. It has been shown in this paper that when the regret principle is used, decisions on insurance may fall into either Case III-A or Case III-B; hence, insurance decisions determined on regret may, or may not, call for randomized behavior.

Some of the important concepts discussed are:

1. Rational decisions, determined by maximizing the minimum average utility, which involve risk require measurable utility.
2. Rational decisions on insurance, determined by maximizing the minimum average utility, do not require measurable utility.
3. The value of the ratio indicating the percentage of times each choice should be made, as determined by Von Neumann and Morgenstern (2), is the *only* value of the ratio which gives the maximum of the minimum average utility.
4. Rational decisions on insurance, determined by maximizing the minimum average utility do not have solutions requiring randomized behavior.
5. Rational decisions involving insurance, determined by minimizing the maximum average *regret*, may require randomized behavior.

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COLLETOTRICHUM GRAMINICOLUM (CES.)

WILSON ON AVENA SPECIES¹

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During recent years *Colletotrichum graminicolum* (Ces.) Wilson has been reported to have caused severe damage to the oat crop in several states in the United States. Some workers consider it as one of the major oat diseases in the south central states.

This study, started during the summer of 1948, was undertaken to determine methods of incorporating resistance to this pathogen into oats. During the previous summer this pathogen had caused some damage in the nurseries at Ames and Kanawha. It was anticipated that it might increase in importance in Iowa as it had further south.

During 1948 and 1949 twenty-one cultures of *C. graminicolum* were isolated from oat plants grown in the nine states: Georgia, Mississippi, Kentucky, Louisiana, Arkansas, Missouri, Illinois, Minnesota, Iowa. One monoonidial culture isolated from oat plants grown in Ohio was supplied by Dr. C. C. Allison of the Ohio Experiment Station. Another culture, isolated from infected wheat plants, was obtained from Dr. C. W. Roane of the Virginia Agricultural Experiment Station.

Of the three methods of inoculation used, foliage, seed, and soil, the first was the most successful. In this method the foliage of the plants was sprayed with a sporemycelial suspension of the pathogen. The inoculum for these inoculations was grown in three different ways. Although virulent inoculum was obtained by growing the organism on sterilized oat stems, large quantities of the inoculum could not be obtained in this manner. The inoculum was grown on potato-dextrose-agar for the tests in 1948. In 1949 the inoculum was

grown on potato-dextrose extract to avoid bacterial contamination. The infection on plants was more severe when the inoculum was grown on potato-dextrose extract, than when it was grown on potato-dextrose-agar. To obtain consistently good infections it was necessary to have free water on the leaves of the plants during the time they were in the moist chamber. Having the plants in a saturated atmosphere was not sufficient. The optimum temperature for obtaining infections was about 25°C., which is 3°C. less than the optimum for the growth of the fungus in media.

No signs of the fungus developed on the plants grown from inoculated seed.

Plants grown in soil infested with *C. graminicolum* were found to be less vigorous, have fewer tillers, and to be lighter green in color than those plants grown in uninfested soil.

The reactions of the 114 "Elemental Varieties" from Dr. T. R. Stanton's varietal classification nursery were tested by foliage inoculations with the organism. In this group some of the Fulghum strains showed some resistance as did the Red Rustproof strains. Some of the varieties derived from Lee x Victoria showed a tolerance to the organism.

Sixty varieties from the Iowa oat breeding nursery and nineteen varieties from the 1948 U. S. D. A. Uniform Rust Nursery were tested for their reaction to foliage inoculation with this organism. The reactions of the Bond derivatives were variable. Reselect Clinton, Andrew, and Taggart were found to be highly susceptible, while Sac, Bonham, and Eaton appeared to be somewhat more resistant. Most of the varieties derived from Victoria x Richland were susceptible. Victoria itself appeared quite resistant.

Foliage inoculations with the pathogen were made to determine the susceptibility of varieties from the following *Avena* species: *Avena byzantina* C. Koch. (cultivated red oat); *A. sativa* L. s. sp. *diffusa* Asch. and Gr. (tree oat); *A. sativa* L. s. sp. *orientalis* Schreb (side oat, common white or northern oat); *A. nuda* L. (hull-less oat); *A. sterilis* L. (wild red or animated

1 a. Chairmen of Committee, H. C. Murphy, Senior Pathologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A., Professor, Depts. of Agronomy and Botany, Agricultural Experiment Station. Iver J. Johnson, Professor, Dept. of Agronomy, Agricultural Experiment Station.

b. Doctoral Thesis No. 1124. Submitted December 7, 1950.

2 a. B. S., University of Nebraska, Lincoln, Nebraska, 1943.
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oat); *A. fatua* L. (wild oat); *A. barbata* Pott (slender oat); *A. abyssinica* Horbst. (Abyssinian oat); *A. nudibrevis* Vav. (small seeded naked oat); *A. wiestii* Steudel (desert oat); *A. strigosa* Schreb. (sand oat) and *A. brevis* Roth (short oat).

All but one of the varieties tested were found to be susceptible. Saia, a variety of *A. strigosa*, was found to be immune to the organism. This variety also was resistant to the crown and stem rust that occurred in the nurseries at Ames and Kanawha in 1949.

None of the 12 cultures of *Colletotrichum graminicolum* isolated from oat plants grown in six states was able to infect the barley varieties Trebi and Moore, or the wheat varieties Pawnee and Iohardi.

This also was true of the culture isolated from oats in 1948 at Ames. The culture isolated from wheat, obtained from Virginia, did not infect the oat varieties Reselect Clinton and Appler, or the barley varieties Trebi or Moore.

Twenty-four varieties of oats were inoculated with the same 12 cultures isolated from oat plants. On the basis of the infection types produced on these varieties no physiological races of the organism could be distinguished among the 12 cultures. There was a difference in pathogenicity of the cultures. Some induced more necrosis, and produced symptoms of the infection sooner following inoculation than did the other cultures.

FACTORS INFLUENCING ORGANISM-BACTERIOPHAGE POPULATIONS¹

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Trials were conducted which involved the use of six strains of lactic streptococci and eight strains of lactic streptococcus bacteriophage to determine the influence of certain factors upon populations of bacteria and bacteriophage. The variables studied consisted of (1) varying the initial counts of bacteria and bacteriophage, (2) combination of a single susceptible organism with two or more active bacteriophages and (3) combining a single active bacteriophage with two or more sensitive organisms. Strains of bacteria and bacteriophage with widely different characteristics were selected. An experimental modification of trypticase soy agar made from a formula suggested by the Baltimore Biological Laboratory, Inc., Baltimore, Md., was used for the enumeration of bacteria by the plate method. Bacteriophage numbers were determined as the most probable number by a three-tube limiting dilution technique. An in-

cubation temperature of 32°C. was used in all trials.

Using one organism-bacteriophage combination, 799,F57, progressively increasing the initial count of bacteriophage particles per milliliter through the range from 25 to 15 million, while holding the initial count of bacteria relatively constant at approximately 200,000 per milliliter had no appreciable effect upon the number of secondary-growth organisms per milliliter, or upon their proliferation rate, but the time required for mass lysis to begin was reduced. Progressively increasing the initial count of bacteria per milliliter through the range from 300 to 100 million, while holding the initial count of bacteriophage particles relatively constant at 25 particles per milliliter, reduced the time required for mass lysis to begin, but when the initial count of bacteria was increased to 100 million per milliliter, mass lysis did not occur. Progressive proportional increases in counts per milliliter of bacteria and bacteriophage had no appreciable effect upon the count of secondary organisms per milliliter at the end of mass lysis. The time required for the initiation of mass lysis was decreased as progressive proportional increases in counts per milliliter of bacteria and bacteriophage were made at and below the

1 a. Chairman of Committee, F. E. Nelson, Professor, Dept. of Dairy Industry, Agricultural Experiment Station.

b. Doctoral Thesis No. 1137. Submitted December 14, 1950.

2 a. B. S., University of Illinois, Urbana, Illinois, 1939.
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level of 13 million bacteria per milliliter and 25,000 bacteriophage particles per milliliter, but mass lysis failed to occur when the initial counts of bacteria and bacteriophage reached levels of 100 million and 450,000 per milliliter, respectively.

With combination 799-F57, mass lysis was not initiated until the counts of both the bacteria and bacteriophage had reached a minimum level of about 10 million per milliliter, except when the initial bacteriophage count was approximately equal to or greater than the initial bacterial count. Within the limitations of the enumeration method used, the secondary organism population appeared to be a relatively constant number at the completion of mass lysis, most values being in the range from 100 to 200 per milliliter.

Population studies employing 13 organism-bacteriophage combinations, with the initial count of the bacteriophage particles maintained at a relatively constant level of 2,500 per milliliter, and the initial count of the bacteria held relatively constant at approximately 200,000 per milliliter, showed that mass lysis usually occurred between 3 and 4 hours following the initiation of the trial. Usually a relatively

constant level of 10 million per milliliter was reached by both the bacteria and the bacteriophage before mass lysis was initiated. The counts of secondary growth organisms at the completion of mass lysis varied from zero per milliliter from four combinations to 450 per milliliter for combination 799-F63. The proliferation rate of the secondary growth organisms in every trial was less than the proliferation rate of the control culture during its logarithmic growth phase.

Based upon bacteriophage sensitivity range, two different types of mutants were obtained when either bacteriophage PF11 or F68 acted upon culture 122-1. Action of bacteriophage F60 on culture 122-1 permitted isolation of only one mutant type. These observations were used as a basis upon which to explain some of the patterns of secondary growth which resulted from other organism-bacteriophage combinations studied in these trials.

The data indicate that the secondary cultures apparently arise as a result of selection by bacteriophage of relatively small numbers of naturally-occurring, bacteriophage-resistant mutants which are present in many lactic cultures.

SOME PROBLEMS IN CHEMISTRY OF URANIUM AND THORIUM OF INTEREST TO THE DEVELOPMENT OF ATOMIC POWER ¹

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The development of atomic power rests primarily on the development of nuclear fission, and especially on the slow neutron fission cycle using uranium as the fissionable material. In addition to the immediate problems of nuclear chemistry and physics which are involved in this cycle, there are many secondary problems the solutions of which are fully as important to the realization of the final goal. The fission plant, or "pile," requires mate-

rials of construction whose nuclear properties and chemical purities must meet critical standards. Chemical processes must be devised for the preparation and purification of these materials. Fission produces fission products whose presence in the pile may be harmful, but whose value when removed and isolated is very great. This requires knowledge of the products of fission, their identity, characteristics, and schemes of chemical isolation. Although thorium itself is not fissionable with slow neutrons, it is useful for atomic power because it can be transformed by neutron absorption and beta-decay to U²³³, which is fissionable. The studies reported in this paper were carried out both to solve problems specifically suggested by the fission process and to add to the

- 1 a. Chairman of Committee, F. H. Spedding, Professor, Dept. of Chemistry; Director, Institute for Atomic Research; Industrial Science Research Institute.
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knowledge of the fundamental nature of uranium and thorium and their compounds.

A STUDY OF SOME BARIUM AND STRONTIUM ISOTOPES PRODUCED IN FISSION

A procedure has been studied for the determination of barium and strontium activities in uranium fission product material which also provides for the recovery of the other fission products. The fission product material was taken into solution and after adding known amounts of inactive carriers, 20-30 mg. of each element concerned, barium and strontium were precipitated as nitrates by adding fuming nitric acid to make the solution 80 per cent HNO_3 . This provided a nearly complete separation from all other fission product elements except antimony, tellurium, and sometimes cerium. Barium and strontium were freed from the foreign activities which coprecipitated from 80 per cent HNO_3 by dissolving the nitrates in water, centrifuging off the insoluble matter, and following with a scavenger precipitation to remove the contaminants. Antimony and tellurium were reuced from the solution by zinc and HCl , and the addition of a few milligrams of ferric nitrate and an excess of NH_4OH served to carry down all hydroxide-insoluble contaminants. The solution was filtered and from the filtrate barium and strontium carbonates were precipitated by the addition of an excess of ammonium carbonate. The precipitation of barium and strontium from a solution containing the indicated foreign activities was less effective as a separation of pure radioactivities than was the procedure involving preliminary removal of the impurities from the solution.

The chromate separation of barium from strontium has been studied by the tracer technique, using radio-strontium from uranium fission. The precipitation of BaCrO_4 from solutions containing 1 gram per liter of barium and varying amounts of strontium yielded precipitates which contained as much as 40 per cent by weight of SrCrO_4 , or which carried down as much as 25 per cent of the initial strontium in the solution, depending on the initial strontium concentration. When the initial strontium concentration was less than 100 mg. per liter, the per cent carried down was practically constant, 20-25 per cent. With equal concentrations of barium and strontium in the initial solu-

tion, approximately 8 per cent of the strontium was coprecipitated, and with 10 times as much strontium as barium, about 3 per cent of the strontium was coprecipitated.

In a study of the radio-strontium produced in fission, the radioactive isotope Sr^{90} was discovered, and Sr^{90} and its daughter Y^{90} identified for the first time in uranium fission product material. Sr^{90} has a half-life of about 17 years, which is the longest half-life of any known strontium isotope. Sr^{90} emits a beta ray whose range has been determined to be approximately 130 mg. Al/cm^2 (0.04 Mev).

DETERMINATION OF THE VAPOR PRESSURE OF URANIUM TETRABROMIDE

The vapor pressure of sublimed UBr_4 was determined by the transpiration method over the temperature range 450°C . to 650°C ., using an apparatus and method modified from that of Jelinek and Rosner (1). The vapor pressure of solid UBr_4 (M. P. 519°C .) can be expressed by the equation:

$$\text{Log}_{10}P_{\text{mm}} = - \frac{10,900}{T} + 14.56. \quad (\text{sublimation})$$

The vapor pressure of liquid UBr_4 can be expressed by the equation:

$$\text{Log}_{10}P_{\text{mm}} = - \frac{7,060}{T} + 9.71. \quad (\text{boiling})$$

From the plot of vapor pressure vs. reciprocal temperature the following heats of change of state have been calculated:

$$\begin{aligned} \Delta H \text{ (sublimation)} &= 50,000 \text{ cal/mol } \text{UBr}_4. \\ \Delta H \text{ (boiling)} &= 32,000 \text{ cal/mol } \text{UBr}_4. \\ \Delta H \text{ (fusion)} &= 18,000 \text{ cal/mol } \text{UBr}_4. \end{aligned}$$

The boiling point of UBr_4 was directly determined to be 765°C ., which checks very closely that calculated from the vapor pressure data (761°C .).

PHYSICAL STUDY OF URANIUM AND THORIUM HYDRIDES

The dissociation pressure of the uranium-uranium, hydride-hydrogen system was studied at 356°C ., and the equilibrium dissociation pressure is essentially constant throughout the range of solid composition 10-90 per cent UH_3 . However the "equilibrium" pressure reached by absorption of hydrogen from a higher pressure is about 14.5 cm. Hg. while that reached

upon partial decomposition of solid into a system of lower hydrogen pressure is about 13.4 cm. Hg. With UH_3 contents below 10 per cent the dissociation pressure tends to decrease. With UH_3 contents above 90 per cent the "equilibrium" pressure of formation is nearly constant to 97 per cent UH_3 before it rises, but the "equilibrium" pressure of decomposition shows a definite reproducible minimum at a composition of about 97 mol. per cent UH_3 . No satisfactory explanation has been found for the difference between the "equilibrium" pressure of formation and the "equilibrium" pressure of decomposition of uranium hydride, nor has one been found for the dip in the decomposition curve. The latter would seem to be theoretically impossible, for a solid of composition intermediate between the dip and the low-hydrogen end of the curve should disproportionate into two phases, one of low hydrogen content, and one whose composition is that at the dip.

The volumes of the U-UH_3 and U-UD_3 systems have been measured by a gas densitometer and found to be linear functions of the hydrogen or deuterium content. The densities of UH_3 and UD_3 have been found to be 10.95 ± 0.1 g./cc. and 11.25 ± 0.1 g./cc., respectively at 25°C .

Hydrogen and deuterium have been fractionated by a partial decomposition of UH_3 - UD_3 mixtures. By this process a separation factor,

$$\frac{N_{\text{D}_2}}{N_{\text{H}_2}} (\text{gas}) \bigg/ \frac{N_{\text{D}}}{N_{\text{H}}} (\text{solid}),$$

of 1.2 has been obtained. The ratio of the vapor pressures of pure UD_3 and UH_3 is 1.4, and it is not understood why the separation factor should be less than this value. While this method can be used for the separation of deuterium from natural hydrogen, it has not yet been used in this separation.

The thorium-hydrogen system has been subjected to a dissociation pressure-composition-temperature study and the existence of two thorium-hydrogen compounds has been proved.

The lower thorium hydride, ThH_2 , is the more stable, and the dissociation pressure of a system whose solid phase contains equal amounts of ThH_2 and Th is given by the equation:

$$\text{Log}_{10} P_{(\text{mm})} = \frac{-7700}{T} + 9.54.$$

The heat of formation of thorium hydride has been determined for the reaction: $\text{Th} + \text{H}_2 \rightarrow \text{ThH}_2$. $\Delta H = -35,200$ cal/mol. The true equilibrium pressure of the system $\text{Th-ThH}_2\text{-H}_2$ is reached in 5 to 10 minutes at 700°C ., either by decomposition or formation of the hydride.

The higher thorium hydride, ThH_x (where x is probably 3.75), is much less stable than ThH_2 . The dissociation pressure of a system whose solid phase consists of equal amounts of ThH_2 and ThH_x is given by the equation:

$$\text{Log}_{10} P_{(\text{mm})} = \frac{-4220}{T} + 9.50.$$

The heat of formation of the higher thorium hydride has been determined for the reaction: $\text{ThH}_2 + (x/2 - 1)\text{H}_2 = \text{ThH}_x$. $\Delta H = 19,300$ cal/mol H_2 absorbed. At 300°C . the "equilibrium" pressure on formation of ThH_x is much higher than that on decomposition, and the true equilibrium pressure is not reached. Both the uranium-hydrogen system and the thorium-hydrogen system of 300 - 350°C . approach equilibrium very slowly and usually fail to reach true equilibrium.

The observed properties of uranium hydride indicate that in most regards this compound can be considered to belong to the saline-compound type of hydride proposed by Ephraim (2). The properties of the hydrides of thorium indicate that these compounds, too, have some saline-compound tendencies, but a consideration of all their properties leads to the conclusion that classification as an alloy-like compound is nearly equally justified. It is likely that the hydrides of thorium and, to a lesser extent, the hydride of uranium are borderline compounds between the two classes.

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ELONGATION OF THE COTTON FIBER¹

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Cotton fiber growth deserves study not only because of its economic importance but also because the cotton fiber is in many ways an excellent plant material for use in investigating the process of cell elongation. Previous studies of cotton fiber development have dealt primarily with secondary wall formation, the differentiation phase of growth. The elongation phase has received much less attention. For this reason the present investigation deals primarily with fiber elongation.

Fiber growth rates were determined under varied temperature conditions for both undisturbed fibers and fibers removed from the plants and grown in sterile nutrient solutions. For the temperature intervals of 15 to 20°C. and 20 to 25°C. temperature coefficients of elongation of more than two were obtained. Although fibers elongated in culture at 15°C., undisturbed fibers on plants kept at this temperature did not grow. Other processes, as well as cell elongation, appear to limit fiber growth at this temperature. Fiber elongation and fiber maturation were found to be closely coordinated with boll growth and maturation, with fiber elongation and boll growth ceasing simultaneously. Growth rates of bolls are influenced by temperature in much the same way as are fiber elongation rates.

A study was made of the sub-microscopic structure of the primary wall of the elongating fiber. Electron-microscope photographs and electron-diffraction patterns were made of the fiber wall. Cellulose in the primary wall exists as strands, or microfibrils, of about 250A diameter and

of lengths of perhaps 50,000A. Microfibrils in the primary wall form a network, being oriented in two principal directions. The outer microfibrils parallel the long axis of the cell, and the inner run at approximately right angles to this axis. Microfibrils of cellulose were found in fibers collected as early as two days after flowering, and in the base, intermediate region, and extreme tip of elongating fibers. In the untreated primary wall cellulose is covered over by pectic substances and waxes. The thickness of the dried primary wall after extraction of waxes was estimated to be 300A. Electron-diffraction patterns of the cellulose of elongating fibers of various ages, including fibers 2 days old, indicated that the cellulose was crystalline, and that the orientation of the crystallites was random.

The carbohydrate and nitrogen content of greenhouse and field grown cotton was determined. Reducing sugars constituted 60 per cent or more of the dry weight of elongating fibers, and decreased in abundance during secondary wall formation. Cellulose constituted only about 3 per cent of the dry weight of elongating fibers, increasing in abundance during secondary wall formation to about 75 per cent in mature fibers. Secondary wall formation appears to be a relatively simple chemical process, consisting of a conversion of glucose to cellulose. Other carbohydrates present in the fibers did not show significant changes during fiber growth and maturation. The nitrogen content of developing fibers decreased slowly from that of 10-day-old to 45-day-old fibers. A comparison of the slow decrease of nitrogen percentages and the constancy of carbohydrate composition during elongation with the great increase in total volume of the fibers indicates that considerable amounts of proteins and cellulose are synthesized during elongation, but that the deposition of cellulose in secondary-wall formation does not begin until elongation is completed.

- 1 a. Chairman of Committee, W. E. Loomis, Professor, Dept. of Botany, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1128. Submitted December 11, 1950.
- 2 a. A. B., University of North Carolina, Chapel Hill, North Carolina, 1943.
- M. A., *ibid.*, 1948.
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APPLICATION OF SCINTILLATION COUNTERS TO BETA-RAY SPECTROSCOPY¹

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The scintillation counter is rapidly proving to be a powerful tool in nuclear studies. Many phosphors have been studied in regard to their usefulness as emitters of light when struck by nuclear particles.

In this work the requirements for the phosphor for beta-ray spectroscopy are considered. Anthracene was chosen as a particularly attractive phosphor for this work.

A scintillation coincidence spectrometer is described. This device was constructed so that it could be used as a scintillation spectrometer without coincidence.

A theoretical investigation of the performance of the instrument for mono-kinetic beta particles is made. This investigation leads to resolution corrections of the experimental beta spectra. Formulae for correcting the experimental data for the poor resolution of the instrument are given.

Cs¹³⁷, Sr⁹⁰, and P³² have end-points which are well known. In obtaining these spectra,

it is demonstrated that end-point determinations of beta spectra can be made with this instrument to an accuracy of 8 per cent or better. With data equally good statistically, end-point determinations for Ag¹¹³ and Ag¹¹² have been found to be 2.0 mev. and 4.2 mev., respectively. By beta-gamma coincidence spectrometry, the inner beta spectrum of Rb⁸⁸ has been found to have an end-point 674 kev. within about 15 per cent.

At a maximum X-ray energy of nominally 70 mev., using the Iowa State College synchrotron to produce Ag¹¹³, and Ag¹¹² from Cd¹¹³ and Cd¹¹⁴, respectively, by a gamma-proton reaction, the ratio of the cross section of Ag¹¹³ to Ag¹¹² is found to be 1.5. The relative yield of Ag¹¹³ to Ag¹¹² equals 2.2.

It is probable that corrections for beta decay forbiddenness can be applied to the data from this instrument. This can be done only when a detailed investigation of the resolution is made.

Because the instrument can investigate activities about 1,000 times as weak as those needed for magnetic spectrometers although its accuracy is not as good, it promises to be a very useful tool for many activities which can be produced by the 70 mev. synchrotron at Iowa State College.

- 1 a. Chairman of Committee, L. Jackson Laslett, Associate Professor, Dept. of Physics, Institute for Atomic Research.
b. Doctoral Thesis No. 1138. Submitted December 14, 1950.
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POLAROGRAPHIC STUDIES OF COMPLEX IONS¹

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The iron-sulfosalicylate complex ions have long been used for the colorimetric determination of iron, but little was known about the identity and stability of these highly colored ions. The complex ion that

imparts the red-violet color to sulfosalicylic acid solutions of ferric iron has been previously investigated by spectrophotometric methods and found to be a one-to-one complex. The yellow-colored, complex ion found in alkaline solution, which is the one most frequently used for the determination of iron, has not been previously investigated, and has been subject to many misconceptions.

In this work the iron-sulfosalicylate, complex system was studied by means of the polarograph. The yellow-colored, fer-

- 1 a. Chairman of Committee, Charles V. Banks, Associate Professor, Dept. of Chemistry, Institute for Atomic Research.
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ric, sulfosalicylate complex in alkaline solutions was the most thoroughly investigated, because of reasons mentioned above, and because it was found to be reduced reversibly to the ferrous ion at the dropping mercury electrode at half-wave potentials that are convenient for polarographic measurement.

The half-wave, potential method, which is the one now used almost universally for polarographic, complex, ions studies, was employed in this work. The equation for the straight line best fitting the data for the variance of the half-wave potential with the logarithm of the concentration of the complexing agent was determined by the method of least squares. The slope of this equation is proportional to the number of molecules of complexing agent participating in the complex ion and the intercept is a function of the instability constant of the complex ion.

In the pH range 8 to 11 the ferric complex was found to contain three doubly-ionized, sulfosalicylate ions and three hydroxyl ions. The molar instability constant of this ion was estimated from polarographic data to be approximately 10^{-23} at ionic strength 1. The number of hydroxyl ions in the complex was confirmed by means of a potentiometric pH titration of ferric acetylacetonate in a known excess of sulfosalicylic acid with a standard, sodium hydroxide solution. In acid solution the half-wave potential of the ferric wave was more positive than the saturated calomel electrode in most cases, so that half-wave, potential method could not be used in this case. In nitric acid solutions the ferric wave was divided into two parts, one more positive than the saturated-calomel electrode, the other about -0.2 volt with respect to this

electrode. The more positive wave is attributed to the aquo ferric ion and the other one to the sulfosalicylate complex of the ferric ion. It is postulated that this latter complex ion also contains nitrate ion, giving more stability, and therefore a more negative half-wave potential for its reduction wave, than the equivalent complex in other supporting electrolytes.

No evidence, polarographic or otherwise, was found for the formation of a complex ion of ferrous iron with doubly ionized sulfosalicylic acid. The ferrous wave was very irreversible, and was therefore useless for study of the possible complex ions by the half-wave, potential method. There was very little shift of the half-wave potential in the presence of sulfosalicylate. At pH values below 4 the ferrous wave was masked by the wave of the hydrogen ion. This is the region where the sulfosalicylic acid is singly ionized. It was thus impossible to determine whether there was complexation between this species of sulfosalicylic acid and the ferrous ion. At pH 9 and above a wave more negative than the ordinary ferrous reduction wave appeared, and seemed to increase in step height with increasing pH. This might indicate a complex of ferrous ion with the triply-ionized sulfosalicylate, which begins to form in this region.

A determination was carried out of the molar constant of the second ionization of sulfosalicylic acid at ionic strength 0.1 by means of the spectrophotometric method. In this case the S-shaped curve best fitting the data for the variation of absorbancy with pH was determined by trial and error and the molar instability constant was determined from this. The value of 0.0032 for this constant fitted the experimental data quite well.

MATHEMATICAL ANALYSIS OF AMYLASE ACTION¹

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The amylases characteristically degrade starch and other alpha 1-4 glucosidic

compounds into reducing and non-reducing saccharides of relatively low molecular weights. Salivary amylase and beta amylase hydrolyze these compounds at the glucosidic bonds to give only reducing products. *Macerans* amylase effects a "glucosidic exchange" in which glucose residues are redistributed among reducing and non-reducing compounds. In this study the reaction products and inter-

1 a. Chairman of Committee, Dexter French, Assistant Professor, Dept. of Chemistry, Agricultural Experiment Station.

b. Doctoral Thesis No. 1087. Submitted July 14, 1950.

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mediates in amylase digestion mixtures were separated, identified and quantitatively determined. From a consideration of these products and the kinetics of the reactions, mechanisms for the action of the amylases are postulated. Equilibrium constants have been determined and are reported for the *macerans* amylase system which has been shown to approach a state of dynamic equilibrium.

In order to follow the action of these enzymes on starch or starch-like compounds, conventional analytical methods including reducing, optical rotation and iodine-complex absorption spectrum determinations were used at first. Later it was found advantageous to use qualitative and quantitative paper chromatographic techniques for analyzing the enzyme digestion mixtures.

Salivary amylase action on amylodextrin or amylose is shown to result in the simultaneous formation of maltose, amylotriase, amylotetraose and high molecular weight dextrans along with minor amounts of compounds intermediate in size between amylotetraose and high molecular weight dextrans. As hydrolysis proceeds the high molecular weight products are degraded eventually leading to a mixture of maltose, amylotriase and amylotetraose. Glucose and maltose are the final products of hydrolysis of amylotriase and amylotetraose.

With amylopectin as substrate, salivary amylase gives a complex mixture of intermediate products including maltose and higher-molecular-weight, linear oligosaccharides together with branched dextrans of unknown structure. While the linear intermediate compounds are degraded in the same fashion as above, the branched dextrans eventually lead to the formation of well-defined, branched oligosaccharides in the tetrasaccharide-heptasaccharide range.

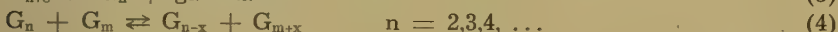
Beta amylase hydrolyzes the linear fractions of starch completely to maltose if the molecule contains an even number of glucose residues or to maltose and one molecule of amylotriase if it contains an odd number of glucose residues. Branched compounds, on the other hand, are hydro-

lyzed only up to the points of structural irregularities in the branched molecules.

It has been demonstrated that not only the rate but also the relative amounts of intermediate products in salivary amylase or beta amylase reaction mixtures are dependent on reaction conditions. The initial products of the action of beta amylase on amyloheptaose at pH 4.5 and 40°C. are maltose and amylotriase and at pH 10.3 and 40°C. they are maltose and amylopentaose. Furthermore, in the intermediate stages of salivary amylase digests of pH 7.0 and 40°C., the only significant, intermediate products of low molecular weight are maltose, amylotriase, and amylotetraose while in digests of pH 10.3 and 40°C. the whole array of linear amylooligosaccharides are present.

On the basis of these findings reaction mechanisms for the action of salivary and beta amylases have been postulated. Salivary amylase action involves a multiple hydrolysis per encounter with substrate molecule before the enzyme and substrate molecules dissociate by diffusion. Thereby the enzyme yields with amylose low molecular weight oligosaccharides together with high molecular weight compounds and with amylopectin a variety of linear and branched saccharides of the type observed. Beta amylase action proceeds by the single-chain process, i.e. an enzyme molecule degrades on substrate chain completely before it attacks another chain. It is suggested that the enzyme is capable of utilizing the energy of glucosidic bonds to hold the enzyme and substrate in oriented positions and as a result the action proceeds by the single chain process. This suggestion though speculative does not seem unreasonable when it is remembered that in muscle tissues enzymes appear to be responsible for the conversion of chemical energy into mechanical work.

Macerans amylase involves a "trans glucosidation" action in which exchangeable glucose residues are redistributed among linear and cyclic glucose polymers. These reactions are reversible and are expressed in equations (1), (2), (3) and (4).



$$m = 1,2,3, \dots$$

$$x = 1,2,3, \dots$$

G_n and G_m are glucose polymers joined by alpha 1-4 glucosidic linkages and contain "n" and "m" glucose residues per molecule, respectively.

At equilibrium the concentrations of the cyclic and linear saccharides will, of course, depend on the initial conditions. However the distribution of the linear saccharides in any equilibrated digest may be found from the distribution function in equation (5).

$$G_n = i(1-i)^{n-1} M. \quad (5)$$

The expressions for calculating the equilibrium constants consequently contain a parameter "i" related to α in Kuhn's

statistical analysis of random hydrolysis of polysaccharides. The introduction of the quantity "i" is justified on experimental and theoretical grounds from probability considerations.

Analytical values for the concentration of linear and cyclic saccharides in an equilibrated amyloheptaose digest were obtained by quantitative paper chromatography procedures. The equilibrium constants for reactions (1), (2), and (3) were found to be 2.1×10^{-2} , 5.6×10^{-3} , and 3.5×10^{-2} respectively. It is suggested that the "i" value concept may be applicable to several other enzymes of the *trans*-glucosidase group.

THE CATALYTIC EFFECT OF ANIONS ON REDUCTION REACTIONS INVOLVING METAL IONS¹

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A model is proposed for a general activated complex AXB in oxidation-reduction reactions involving two metal ions (A) and (B). The symbol (X) would indicate the anions or other groupings which might be present, and which ordinarily would be complexed to the metals separately. The effectiveness of (X) is related to its ability to be oxidized or reduced in itself. In the case that (X) consists of oxidizable anions, the probability of electron transfer from (X) to the oxidizing metal (A) is correlated with the strength (energy) of the bond between (X) and (A). Two previous explanations of the catalytic effect of anions on such reactions are discussed, and some experiments outlined which will test the validity of the proposed model.

The disproportionation of uranium (V) is of interest because it occurs between like charged ions and because an excess proton is necessary for reaction. The rates of disproportionation are studied in heavy and light water in an attempt to distinguish between paths in which a proton or deuteron is involved and those in which

our (X) grouping is OH^- or OD^- . Of the two courses, the latter is judged to be more likely and the reaction is therefore placed in the general class of anion catalyzed oxidation-reductions.

In the next study, it is confirmed that the chloride catalyzed ferric-stannous reaction is first order in ferric ion concentration. In the range of chloride ion concentrations studied, fourth order dependence on chloride is dominant. It is probable that a minimum of three is required in the activated complex for any appreciable reaction rate. When bromide is added, a third-order dependence is observed. Only two iodide ions appear necessary for reaction, but third-order dependence may be important at higher iodide concentrations. The reaction is depressed when large amounts of metal ions are present due to the complexing and removal of halide ions. This is markedly so in the case of high stannous ion concentrations. Approximate values for the equilibrium constants for the formation of SnCl^+ and SnBr^+ are estimated. In the order of increasing effectiveness in promoting reaction we have that Cl^- is less than Br^- is less than I^- . Attention is directed to the fact that the complexing affinity of the halides for both ferric and stannous ions decreases in this order, while the order observed is the order of increasing ease of oxidation of the halide ions.

In the next studies, it is found that hexammine-cobaltic ion is reduced by

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- b. M. S., *ibid.*, 1948.
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stannite ion by a path independent of the cobalt concentration. Instead, the reaction is first order HSnO_3^- and OH^- . No significant amount of SnO_2^- is found, but some dimerization of the stannite is necessary to explain the results. When the hydroxypentammine-cobaltic ion is used, the reaction is similarly zero order in cobalt, showing that one anion is insufficient. When the complex is allowed to stand in strong basic solution, the reaction is faster and a bimolecular path is possible. It is found that chloride ion will not accelerate these reactions, but traces of

cyanide ion will. Cyanide is the only anion tried which can displace ammonia from the complexes. Stannite will apparently not reduce the hexacyanocobaltate (III) ion because of an adverse over-all free energy change.

The probable generality of the model is discussed and the results applied to the explanation of the rates of some of the isotope exchange reactions which have been studied recently. It would seem that some account must be taken of the equivalence of the oxidation changes in the two reactions as well.

CONDUCTANCES, TRANSFERENCE NUMBERS, AND ACTIVITY COEFFICIENTS OF CHLORIDES OF SOME LOW ATOMIC NUMBER RARE EARTHS IN AQUEOUS SOLUTION¹

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The conductances, transference numbers, and activity coefficients of aqueous solutions of the chlorides of lanthanum, cerium, praseodymium, and neodymium have been determined for concentrations up to 0.1 normal. The transference numbers were determined by the moving-boundary method as developed by Longworth and MacInnes (1); the activity coefficients were measured by using concentration cells with transference; and the conductances were obtained with a conventional apparatus of the type recommended by Jones and Josephs (2). The accuracy of all measurements was within 0.1 per cent.

The data for all four rare earths agree with the Onsager limiting law up to about 0.002 normal. A comparison of the data with those for samarium, europium, and ytterbium chlorides recently determined at Iowa State College by Spedding and Wright (3), indicates that there is a regular decrease in the conductances of solutions of the rare-earth chlorides with increasing atomic number beginning at about neodymium. The chlorides of lanthanum, cerium, and praseodymium have about the same conductances, while the

conductance of neodymium chloride is slightly higher. The behavior of the first four rare earths is thus anomalous in that the rare earths would be expected to show a regular change in properties over the whole series. A possible explanation of the observed data is that a second coordination number may become possible as the ions become larger with decreasing atomic number, so that an equilibrium may be set up between two kinds of hydrated ions having different coordination numbers. Such an alteration in the coordination numbers should produce substantial changes in the effective radii of the hydrated ions which would greatly influence their conductances. The importance of the degree of hydration of the ions in determining the conductance of the solution is indicated by the fact that, in the latter part of the rare-earth series, the conductances decrease with decreasing ionic radius as measured crystallographically. The greater mobility which should result from the smaller ion is more than compensated by the effects of hydration. At the present time, insufficient data are available for any definite conclusions to be made; measurements of conductances should be extended to all members of the rare-earth series not only for chlorides but also for other salts of different anion valence types. In addition, more crystallographic data on hydrated salts would be useful, in order to study the coordination numbers of the hydrated ions and to correlate them with the conductive behavior.

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The transference numbers do not merge with the theoretical Onsager limiting slope. This is somewhat surprising in that the conductances are in excellent agreement with the Onsager equation and do merge with the limiting slope at concentrations as high as 0.002 normal. It is evident that some effect must be influencing the motion of the ions which cancels out in the case of conductance, but which causes a difference in the case of transference numbers. The data presented, together with those of Spedding and Wright (3) for samarium, europium, and ytterbium salts, indicate that the same effects which cause the conductance results for the first four elements to behave in an unexpected manner, also produce an analogous effect in the case of transference numbers. Little change in transference numbers is observed for the first four rare earths; however, beginning with neodymium a regular decrease with increasing atomic number is observed.

An effort should be made to extend the transference number measurements to higher dilutions in order to find an explanation for the fact that the Onsager equation is followed for conductance, but not for transference numbers. In addition, data for all the rare earths should be accumulated, so that a more complete study can be made of the factors entering into the ion mobilities.

The activity coefficients for all four salts agree well with the Debye-Hückel theory. The values obtained for a' , the average

effective ionic diameter, show no regular decrease, but do show an increase up to neodymium. As in the case of conductances, this effect may be due to the simultaneous existence in solution of two coordination numbers for the rare earth ions of low atomic number. The a° values for all four rare earths exceed the sum of the ionic radii of the rare earth ions and the chloride ion by approximately the diameter of one water molecule. If the a° values have physical significance, the above fact indicates that the first sheath of water molecules adheres tightly to the rare earth ion. The diameter of this sheath would undoubtedly depend largely upon the coordination number of the central ion; hence, if an equilibrium were established between two coordination forms in solution, the magnitude of a° , which is an average property, would depend upon the point of the equilibrium. Variations in the point of the equilibrium for the first four elements could thus possibly provide an explanation for the observed distances of closest approach.

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2. JONES, G., AND R. C. JOSEPHS
1928. *J. Amer. Chem. Soc.* 50: 1049-92.
3. SPEDDING, F. H., AND J. M. WRIGHT
Unpublished work.

ESTIMATION OF STARCH IN PLANT TISSUE¹

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A great many problems in plant physiology require an analysis of plant tissue for its starch content. The method of starch determination used most frequently by plant physiologists involves extraction of soluble carbohydrates with 80 per cent alcohol and dextrans with 10 per cent alcohol. The material is then heated to gelatinize the starch, subjected to enzymatic

extraction, cleared, filtered and de-leaded. The resulting solution is hydrolyzed with acid, neutralized and the resulting glucose determined by some suitable means. The starch is then calculated with a conversion factor of 0.9. In this work the various phases of the above method were studied.

It was found that the plant material should probably be ground in a Wiley mill to pass through a 40 to 80 mesh screen. However, it was shown that the optimum degree of grinding probably varies with the plant tissue being studied. Whereas insufficient grinding might prevent complete extraction of the starch, too

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much grinding, especially in a ball mill, caused a change in the starch and might cause the extraction of non-starch substances with the starch.

The extent of heating to gelatinize the starch is probably not critical. Although heating at atmospheric pressure was not used, heating at 5 to 20 pounds pressure for 30 minutes and at 15 pounds for 30 to 90 minutes did not effect the results. Lower values, however, were obtained if the material was not subjected to any heating.

Salivary diastase is considered to be superior to taka-diastase in the enzymatic extraction. Incubation with saliva beyond two hours did not significantly increase the recovery of starch. It was noted that with long incubation periods (over 12 hours) there is a danger of loss of starch, probably through microbiological action.

Lead clearing of the enzymatic digest was shown to be necessary with Abutilon leaves, where nearly half of the hydrolyzable extractives were removed by lead. If this step is omitted with other materials, it should be established that such an omission has no effect on the results. When the plant extract is cleared, it is necessary to precipitate the excess clearing (Pb) with dibasic potassium phosphate. Caution must be used in this step to prevent the addition of too great an

excess of phosphate, which will cause high readings.

It was found that heating in the autoclave with 1 + 80 HCl for 30 to 60 minutes at 15 pounds pressure would bring about maximum hydrolysis of the enzymatic extract. It is desirable to keep the concentration of HCl as low as possible since the NaCl formed on neutralization would tend to give high results.

Certain optimum conditions were determined for the estimation of starch:

Grinding to 40 to 80 mesh

Gelatinization in an autoclave for 30 minutes at 15 pounds pressure

Incubation of the sample with ± 3 ml. of 50 per cent saliva for two hours

Clearing with lead acetate, filtering and deleading with a slight excess of K_2HPO_4

Hydrolysis of the extract with 1 + 80 HCl at 15 pounds for 30 to 60 minutes

Determination of the reducing sugars formed.

Various plant tissues were analyzed using the optimum conditions found for the method. The results of these analyses indicated that non-starch substances were sometimes determined as starch and that there is probably no completely adequate method for the determination of starch in all plant tissues.

RELEASE OF POTASSIUM FROM NONEXCHANGEABLE FORMS IN IOWA SOILS¹

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The release of K from nonexchangeable forms in 13 Iowa soils was measured by cropping with alfalfa in pots in the greenhouse. Nine successive cuttings of alfalfa plus the roots after the last cutting were harvested and the total K removed from the soils was determined by an analysis of the plant materials. The amount of K released from nonexchangeable forms to the alfalfa was calculated by subtracting

the decrease in exchangeable K during the cropping period from the total K removed by the alfalfa.

The release of K from nonexchangeable forms was also measured by a 10-minute extraction with boiling 1.0 N HNO_3 , by moist incubation with equal parts of soil and Dowex-50 cation exchange resin for a 2-month period, and by incubation for a 10-week period with 1.0 N $MgCl_2$. In each of these procedures the K release was calculated by subtracting the exchangeable K from the amount of K extracted with the extractant being used. Total K was determined for all of the 13 soils.

The correlations between K release from nonexchangeable forms by cropping and

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the K release from nonexchangeable forms by laboratory methods were studied. The relationships between the total K removed by cropping and the amounts removed by laboratory methods were also studied.

Size fractions of the 13 soils used in the greenhouse-cropping work were obtained by sedimentation and by the use of a Sharples' supercentrifuge. The size fractions thus obtained were extracted with boiling 1.0 N HNO_3 for a 10-minute period. The exchangeable K was determined on all fractions so that the release of K from nonexchangeable forms to HNO_3 could be calculated. Size fractions of eight soils were analyzed for total K and size fractions of three soils were incubated for 10 weeks with 1.0 N MgCl_2 . The release of K from nonexchangeable forms to HNO_3 divided by the total K in the fractions was taken as a measure of the susceptibility of the K in the fractions to extraction by HNO_3 .

Fixation studies were conducted for six soils to determine the effect on K fixation of K release by cropping, and by laboratory extraction methods. Potassium fixation was measured under moist conditions and on drying.

From the above described investigation the following conclusions appear to be justified.

1. In greenhouse-cropping experiments the K status of Iowa soils can be accurately assessed by the determination of the exchangeable K. A better assessment can be made by measuring both the

exchangeable K and the K that is re-released from nonexchangeable forms to Dowex-50 cation exchange resin.

2. The release of K from nonexchangeable forms to Dowex-50 cation exchange resin or to HNO_3 is a good index to the amount of K release to cropping in the greenhouse.
3. The K release from nonexchangeable forms in Iowa soils by extraction with MgCl_2 is significantly correlated to release of K by cropping with alfalfa in the greenhouse. Since clay was shown to fix K into nonexchangeable forms when extracted with MgCl_2 , the release of K from nonexchangeable forms by this extraction procedure is from the silt fractions.
4. For the 13 soils studied in this investigation, about 60 per cent of the K release from nonexchangeable forms comes from the clay fractions and about 40 per cent comes from the silt fractions.
5. The K level in the soils of Iowa is not a function of any given size fraction. The K release from any silt or clay fraction in these soils can be expected to be significantly correlated with the release from the whole soil. A soil that gives high amounts of K release, in comparison to a soil that gives low amounts of K release, does so as a result of higher release from each size fraction in the soil rather than as a result of the presence or absence of one particular size fraction.

NUCLEAR DISINTEGRATION STUDIES WITH A BETA-RAY SPECTROMETER¹

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The use of a beta-ray spectrometer, in the analysis of nuclear decay schemes, makes possible the solution of many of the problems which arise in the course of such analyses. Of particular interest is the application of the instrument to the determination of the energy of beta- and gamma-radiation from radioactive iso-

topes. In addition, it is possible to use the instrument to estimate the relative intensities of the various components of radiation, and to apply the coincidence method, in conjunction with the spectrometer, to the determination of the order in which these components are emitted from the nucleus.

The present work was concerned with three particular problems arising in beta-ray spectrometry.

A method of improving the intensity-resolution relationship of a thin lens magnetic beta-ray spectrometer, by means of ring focusing, was investigated. The existence of a ring-shaped constriction in the

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electron beam was demonstrated experimentally by a photographic film method. Making use of the photographic mapping of the beam, an annual baffle was designed. Optimum relations between annular-width, solid-angle and counter-window diameter were investigated. A comparison of this type of baffle system with the original baffle system showed that at 2.5 per cent resolution the spectrometer transmission may be increased by a factor of two by the use of an annular aperture in the region of beam constriction.

A theoretical analysis was carried out in an attempt to determine relations from which the relative intensities of beta-rays, gamma-rays and internal conversion electrons might be determined from data obtained with the spectrometer. Simplifying assumptions were made concerning the focusing action of the instrument, and effects due to scattering of electrons in the source of photoelectric radiator were neglected. Formulae were derived from which the observed spectrometer counting rates due to sources of known activity, emitting beta-rays, gamma-rays or internal-conversion electrons may be predicted.

The results may be expressed in terms of a quantity defined as the spectrometer efficiency e_s . If internal-conversion electrons are being counted, e_s is defined as the ratio of spectrometer counting rate at the peak of the spectral line to the rate of emission of internal-conversion electrons by the source.

If beta-rays are being counted, e_s is defined as the ratio of spectrometer counting rate at any arbitrary value of the focusing current to the rate of emission of beta-rays by the source. The efficiency in this case will thus be a function of the focusing current. If gamma-rays are being counted by the detection of photoelectrons emitted from a radiating foil, e_s is defined as the ratio of spectrometer counting rate at the peak of the spectral line to the rate of emission by the source of the gamma-quanta concerned.

The results for these three cases are:

$$e_s \text{ (internal conversion electrons)} \\ = e_0 S(a),$$

$$e_s \text{ (beta-rays)} = e_0 h p_0 n(p_0)/N,$$

$$e_s \text{ (gamma-rays)} = e_0 S(a) \tau X.$$

The notation used is as follows: The quantity e_0 is the efficiency of the spectrometer for counting monoenergetic electrons and is thus the product of the fractional solid angle collected and of the intrinsic efficiency of the spectrometer

counter. $S(a)$ is a function of the parameter a given by:

$$S(a) = (1-a/2) \text{ for } a < 1;$$

$$S(a) = 1/2a \text{ for } a > 1.$$

The parameter a is the ratio of the momentum loss of an electron of momentum p_0 in traversing the source or photoelectric radiator to the base of the spectrometer transmission curve, where p_0 , the focused momentum, is the momentum of the electrons selected by the spectrometer baffle system. The quantity h is the fractional half-width ($\sigma p/p_0$) of the transmission curve. The function $n(p_0)$ is the rate of emission of beta-particles per unit momentum interval, and N is the total rate of emission of beta-particles by the source. The factor τ is the photoelectric absorption coefficient of the radiator for the orbital shell concerned, and X is the thickness of the photoelectron radiator.

Due to the assumptions made, the accuracy of these formulae is such that they furnish an estimate only. It is suggested, however, that they may be treated as semi-empirical relations by means of which data may be reliably interpolated.

The application of the spectrometer to the methods of coincidence counting has been considered. Statistical considerations may be used to predict the limitations of the spectrometer with respect to the types of coincidence measurements which may be carried out successfully. The methods of coincidence spectrometry were applied to an analysis of the decay scheme of Hf^{181} . Both electron-electron and gamma-electron coincidences were investigated. The efficiency of the gamma-counter used was determined by coincidence methods, using the known decay schemes of Co^{60} and ThB .

The results of the measurements indicated delayed coincidences between the beta-particles and the gamma-ray transitions of 130 Kev and 471 Kev energy.* They also indicated non-delayed coincidences between the 130 Kev and 471 Kev gamma-ray transitions. The part of the Hf^{181} decay scheme involving these transitions, proposed by Chu and Wiedenbeck,* is thus confirmed by these measurements. The results do not serve to distinguish between the complete decay scheme of Chu and Wiedenbeck and modifications such as that proposed by Deutsch and Hedgran.**

* Chu, K. Y., and Wiedenbeck, M. L. The Radiations From Hf^{181} , *Physical Review* 75: 226-31, 1949.

** Deutsch, M., and Hedgran, A. Radioactivity of Hf^{181} , *Physical Review* 79: 400-01, 1950.

GENETIC VARIATION AND COVARIATION IN PRODUCTIVE CHARACTERS OF NEW ZEALAND ROMNEY MARSH SHEEP¹

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The main purpose of the study was to determine the heritability of the productive traits and the genetic correlations among them to serve as a basis for discussing selection as a means of improving productivity in the New Zealand Romney Marsh breed. The study also yielded information on the effects of type of birth, age of dam, year, and age at shearing on the yearling traits, information on the phenotypic correlations among the traits and information on the presence of interaction between sires and years.

The traits studied were: greasy fleece weight, staple length, count, fleece quality, hairiness and body type. These traits were recorded at 14 months of age on 697 ewes which had been shorn as lambs at weaning. Body weight at 9 months was included in part of the analysis.

Some of the problems encountered in analyzing the data led to the development of new techniques. (1) An approximate standard error for the genetic correlation between two traits was found by using large sample methods. (2) A method of including in a selection index a character expressed as the square of the deviation from an optimum was presented. Such a transformation seemed suited to characters in which the intermediate expression is preferred over high or low values. In the present case, it was used to include count in the selection index since previous results had shown that there is an optimum count for each class of country. (3) To obtain scores for the grades used in describing a character subjectively, the criterion of maximizing the regression of daughter on dam was used. This criterion is equivalent to maximizing the estimated heritability of the character. An example of the analysis applied to the data for fleece quality was given.

Fleece quality was the only trait in which the interaction between sires and years was significant. Whether this interaction was due to genuine interaction between heredity and environment, or to non-additive gene effects, or to varying emphasis being placed on the component characters in the description of fleece quality, could not be decided from the data.

Differences between singles and twins were most marked for fleece weight (0.22 pound) and body weight at nine months (6.65 pounds). Differences between yearlings mothered by five-year-old ewes and by two-year-old ewes were important for fleece weight (0.54 pound), staple length (0.54 centimeter) and fleece quality (0.42 score). Correction for the above effects is worth while in improving the accuracy of selection. Yearlings mothered by two-year-old ewes were little different from those mothered by three-year-old ewes.

Only records taken at mature ages were available for some of the dams. Hence, heritabilities calculated from the regression of the yearling record of the daughter on the mature record of the dam could be compared with those calculated from the regression of the yearling record of the daughter on the yearling record of the dam. Though the heritabilities from the latter method were generally higher, the differences were not significant. The variance of the mature records was significantly different from that of the yearling records for fleece weight only. The combined estimates of heritability were:

Count	0.27 ± .05
Staple length	0.35 ± .07
Fleece quality	0.22 ± .07
Hairiness	0.63 ± .06
Body type	0.14 ± .07

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The heritability of fleece weight was 0.11 from the regression on mature record of the dam and 0.31 from the regression on yearling record of dam.

The genetic correlations among the traits were:

TABLE 1

	Staple length	Fleece quality	Fleece weight	Hairiness	Body type
Count.....	-0.73	0.21	-0.47	-0.30	0.08
Staple length.....		0.13	0.25	0.41	0.21
Fleece quality.....			0.08	-0.12	0.48
Fleece weight.....				0.28	0.06
Hairiness.....					-0.30

The standard errors of these genetic correlations ranged in size from 0.11 to 0.22. The genetic correlations which are expected to limit improvement from selection result in these associations: (1) Selecting for finer count gives shorter staple length and lower fleece weight; (2) selecting for higher fleece weight, longer staple or coarser wool leads to increased hairiness.

Relative economic values for the traits were calculated from the price schedule used in appraising wool during 1943-44 and from the export meat prices for the same years. They were: fleece weight (15), count (4), fleece quality (3), staple length (2), body type (4) and hairiness (3), for each unit change in the traits.

Using the above data, three selection indexes were calculated. In I_1 , count was expressed as the square of the deviation from an optimum of 8 units (48/50) on the count scale. In I_2 , count was not transformed while, in I_3 , count was omitted altogether. The indexes are:

$$I_1 = 0.68 L + 0.76 Fl + 1.81 F.W. + 2.54 H + 0.56 B + 0.18 C_1$$

$$I_2 = 1.70 L + 1.13 Fl + 2.46 F.W. + 0.32 H + 0.59 B + 2.82 C$$

$$I_3 = 0.61 L + 0.79 Fl + 1.92 F.W. + 1.89 H + 0.61 B$$

where: L = length of staple in centimeters

Fl = fleece quality score

F.W. = greasy fleece weight in pounds

H = hairiness in logarithmic units

B = body type score

$C_1 = -(C - 8)^2$, C being the score for count

The results expected from using these indexes show that there is no need to express count as the square of a deviation from an optimum. If the optimum count is coarser than the flock average, I_3 is nearly as satisfactory as I_1 in selecting for coarser wool. If the optimum count is finer than the flock average, use of I_2 results in selection for finer wool. The uncertainty about the true sizes of the genetic correlations and relative economic values is the main factor which may cause the indexes to be far from achieving their purpose of maximizing the rate of improvement from selection. Despite this uncertainty, the indexes use the information available at the present time to the best advantage in making selection as efficient as possible.

A STRUCTURAL STUDY OF THE METALLIC COMPOUND TiBe_{12} ¹

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The metallic compound, TiBe_{12} , crystallizes in the hexagonal system with the lattice constants $a_0 = 29.44 \pm .01$ Å, $c_0 = 7.33 \pm .01$ Å. The Laue diffraction class is D_{6h} and the space group of the final structure is D_{6h}^1 ($C6/mmm$).

The observed absences of reflections with even l index allow the problem to be separated into two simpler problems. The first of these, that of determining a pseudo cell structure from reflections with even index, has been solved satisfactorily.

The pseudo cell (determined by the reflection with even indices) has the lattice constants $A_0 = 4.33$ Å, $C_0 = 7.33$ Å. The angle between a_0 and A_0 is 90° , while c_0 and C_0 have the same direction.

The structure of the pseudo cell has been found and the atoms have the following positions in D_{6h}^1 :

- 1 a. Chairman of Committee, R. E. Rundle, Professor, Dept. of Chemistry, Industrial Science Research Institute, Institute for Atomic Research.
- b. Doctoral Thesis No. 1101. Submitted August 18, 1950.
- 2 a. A. B., University of Louisville, Louisville, Kentucky, 1943.
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- 1 Ti in (a) 000 ; or (b) $00\frac{1}{2}$
- 2 Be in (e) $00z$; $00\bar{z}$; z near $\frac{1}{4}$
- 6 Be in (i) $\frac{1}{2}0z_1$; $0\frac{1}{2}z_2$; $\frac{1}{2}\frac{1}{2}z_3$; $\frac{1}{2}0\bar{z}_3$;
 $0\frac{1}{2}\bar{z}_2$; $\frac{1}{2}\frac{1}{2}\bar{z}_1$; with z_2 near $\frac{1}{4}$
- 2 Be in (c) $\frac{1}{3}$, $\frac{2}{3}$, 0 ; $\frac{2}{3}$, $\frac{1}{3}$, 0
- 2 Be in (d) $\frac{1}{3}$, $\frac{2}{3}$, $\frac{1}{2}$; $\frac{2}{3}$, $\frac{1}{3}$, $\frac{1}{2}$.

It will be seen that the titanium atoms may lie at $z = 0$ or $z = \frac{1}{2}$, and it is this titanium position which distinguishes the various pseudo cell portions of the real cell.

In the real cell the ambiguity which characterizes the titanium positions in the pseudo cell is only partially resolved. All possible ordered structures in all allowed space groups have been investigated and intensity agreement cannot be obtained with any such ordered structure. It is necessary, therefore, to postulate a partially disordered structure, in which the various titanium atoms in the real cell occur at $z = 0$ with a definite probability.

One set of probabilities has been found

in D_{6h}^1 which explains the remarkable absences in the reflections with odd l index and which also places adjacent re-

TABLE 1
THE PROBABILITIES THAT THE TITANIUM ATOMS OCCUR AT $Z = 0$ IN TiBe_{12}

Titanium positions	Probabilities
$0,0$; $1/3,2/3$; $2/3,1/3$	$1/4$
$1/4,0$; $0,1/4$; $3/4,3/4$; $3/4,0$; $0,3/4$; $1/4,1/4$	$3/4$
$1/2,0$; $0,1/2$; $1/2,1/2$	$3/4$
$1/2,1/4$; $3/4,1/2$; $3/4,1/4$; $1/4,1/2$; $1/2,3/4$; $1/4,3/4$	1
$7/12,2/12$; $10/12,5/12$; $7/12,5/12$; $2/12,7/12$; $5/12,10/12$; $5/12,7/12$..	$1/8$
$5/12,1/12$; $11/12,4/12$; $8/12,7/12$; $1/12,5/12$; $4/12,11/12$; $7/12,8/12$; $8/12,1/12$; $11/12,7/12$; $5/12,4/12$; $1/12,8/12$; $7/12,11/12$; $4/12,5/12$	$1/2$
$1/12,2/12$; $1/12,11/12$; $10/12,11/12$; $2/12,1/12$; $11/12,1/12$; $11/12,10/12$	$1/2$
$4/12,2/12$; $10/12,8/12$; $10/12,2/12$; $2/12,4/12$; $8/12,10/12$; $2/12,10/12$	$1/8$

flections in the correct order. The atomic positions of the titaniums and the probabilities that they occur at $z = 0$ are given in Table 1.

While this structure may not be unique, it does explain all the observed data fairly well.

A study of Fourier transforms was of considerable help in the structure determination. The following formula is one important result of this study.

$$\int_0^1 \rho(xyz) \cos 2\pi l_1 z dz$$

$$= \frac{1}{V} \sum_{-\infty}^{+\infty} \sum_{-\infty}^{+\infty} F(hkl_1) \cos 2\pi (hx + ky)$$

where ρ is the electron density function and l_1 is a fixed value of l . This formula allows Fourier syntheses, made with the data obtained from a single reciprocal lattice layer, to be interpreted.

FORCE FIELDS IN WHICH CENTERS OF GRAVITY CAN BE DEFINED¹

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INTRODUCTION

In this thesis, an attempt is made to clarify the concept of center of gravity, and to determine what force fields admit of a center of gravity. To this end, two distinct definitions of center of gravity are given.

Definition 1. A force field F is said to admit of a center of gravity in a first sense if, corresponding to an arbitrary mass system placed in the force field, there exists a point called the center of gravity for which the following conditions are satisfied:

1. The resultant force acting on a mass system is the same as the force that would act on a particle placed at the center of gravity, if this particle had a mass equal to the total mass of the system.
2. The center of gravity stays fixed in a mass system as the system undergoes arbitrary rigid body translations and rotations.

Definition 2. A force field F is said to admit of a center of gravity in a second sense if, corresponding to an arbitrary mass system placed in the force field,

there exists a point called the center of gravity for which conditions "1" and "2" are satisfied, but for which a third condition is also satisfied. This condition is as follows:

3. A mass system, if thought of as rigid, has no tendency to rotate about its center of gravity.

John Aczél and Stephen Fenyo³ have considered force fields which admit of a center of gravity which satisfies conditions "1," "3" and another condition which requires that the center of gravity for two particles lie on the line joining the particles.

Let points in space be designated by the position vector R and let the force per unit mass at a point R of the force field be given by the vector function $F(R)$. In the next section there is determined the most general class of functions $F(R)$ which are continuous in some open region of space and which define force fields that admit of a center of gravity according to *Definition 1*. The class of force fields so determined is then restricted in such a way as to admit of a center of gravity according to *Definition 2*. Henceforth, the force field F and the vector function $F(R)$ that defines F are referred to as the same quantity.

DETERMINATION OF FORCE FIELDS

Force Fields That Admit of a Center of Gravity in the First Sense

A mass system consisting of two identical particles, of mass M , and located at the points R_1 and R_2 is first considered. It is

- 1 a. Chairman of Committee, H. P. Thielman, Professor, Dept. of Mathematics.
b. Doctoral Thesis No. 1177. Submitted June 8, 1951.
- 2 a. B. S., University of Colorado, Boulder, Colorado, 1947.
b. Graduate Assistant, Dept. of Electrical Engineering.
- 3 John Aczél and Stephen Fenyo. "On Fields of Force in Which Centers of Gravity Can Be Defined." *Hungarica Acta Mathematica*. 1,3:53-60, 1948. (Original article not available, reprint used.)

easily shown that, if condition "2" is to be satisfied, then the center of gravity R_c must be

$$R_c = \frac{R_1 + R_2}{2}. \quad (1)$$

Since $F(R)$ represents the force on a unit

defined by equation (4). It is next shown that this force field actually possesses a center of gravity in the first sense.

Let a mass system be considered which consists of particles of mass M_i located at the points R_i , $i = 1, 2, \dots$, and of continuously distributed mass of density $D(R)$. If this mass system is placed in a force field of a type defined by equation (4), then condition "1" requires

$$\begin{aligned} & (\sum_{i=1} M_i + \int_V D(R) dv) (\psi \cdot R_c + B) \\ &= \sum_{i=1} M_i (\psi \cdot R_i + B) + \int_V D(R) (\psi \cdot R + B) dv. \end{aligned} \quad (5)$$

This equation is satisfied if

$$R_c = \frac{\sum_{i=1} M_i R_i + \int_V D(R) R dv}{\sum_{i=1} M_i + \int_V D(R) dv}. \quad (6)$$

mass placed at the point R , condition "1" along with equation (1) requires

$$\begin{aligned} & F(R_1) + F(R_2) \\ &= 2F\left(\frac{R_1 + R_2}{2}\right). \end{aligned} \quad (2)$$

The solution of this functional equation can be reduced to the solution of nine functional equations of the Cauchy type, that is, equations of the type⁴

$$f(x + y) = f(x) + f(y). \quad (3)$$

By this method, it follows that the most general function that satisfies (2) and which is continuous in some open region of space is

$$F(R) = \psi \cdot R + B, \quad (4)$$

where ψ is an arbitrary constant dyadic and B is an arbitrary constant vector.⁵ Thus, if there exists a force field F which is continuous in some open region of space, and which admits of a center of gravity according to *Definition 1*, then $F(R)$ is

This value of R_c also satisfies condition "2". Thus it is seen that, if F is given by equation (3), then there does exist a center of gravity which satisfies *Definition 1*. This completes the proof of the following theorem.

THEOREM 1.

If $F(R)$ is continuous in some open region of space, then a necessary and sufficient condition that there exists a point that satisfies conditions "1" and "2" for arbitrary mass distributions is that $F(R)$ be given by equation (4). In this case the center of gravity is given by equation (6).

Force Fields That Admit of a Center of Gravity in the Second Sense

By the consideration of a special mass system that consists of two identical particles located at the points R_1 and $2R_1$, it follows readily that, if $F(R)$ is given by equation (6), then there can exist a center of gravity which satisfies condition "3" only if ψ is a scalar K times the idemfactor. It also follows that if ψ is a scalar K times the idemfactor, then a point does exist which satisfies condition "3" for an arbitrary mass distribution. These results along with THEOREM 1 prove a second theorem.

THEOREM 2.

If $F(R)$ is continuous in some open region of space, then a necessary and sufficient condition that there exist a point which satisfies conditions "1", "2", and "3" for an arbitrary

4 Emile Picard. *Lecons sur quelques equations fonctionnelles*. Paris, Gauthier — Villars. 1928. P. 3.

5 This result can also be obtained directly from equation (2) by a method similar to that used by Picard to solve equation (3).

mass distribution is that $F(R)$ be given by the equation

$$F(R) = KR + B,$$

where K is an arbitrary constant scalar and B is an arbitrary constant vector. The center of gravity is given by equation (6).

In addition, the results stated by the above theorems are discussed, and special cases are illustrated by figures. It is shown that THEOREM 2 can be derived on the basis of THEOREM 1 and the results of Aczél and Fenyő.

RESPONSES OF CORN TO 2,4-DICHLOROPHENOXYACETIC ACID¹

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The use of selective herbicides has been practiced for many years in weed control programs, but the widespread utilization of 2,4-dichlorophenoxyacetic acid (2,4-D) is a relatively recent development. The high degree of selectivity shown by this chemical, particularly in low concentrations, enables it to fit well into various types of weed control programs. Comparatively small dosages control numerous broad-leaved weeds and have little or no effect upon most grass and cereal-crop plants.

Corn is one of the crops that have been extensively treated with 2,4-D. The resistance of the plant varies with varieties, with season and probably with weather conditions. Yields are reduced by spraying just before tasseling, and sometimes by earlier sprays. The development of stalk brittleness when the plant is sprayed at the 10-leaf (knee-high) stage may result in serious stalk breakage if the field is cultivated or if high winds occur shortly after spraying.

This investigation was concerned with the effects of one-half-pound and one-pound-per-acre rates of 2,4-D on corn inbreds WF9 and W22 and single-crosses WF9 x Os420 and W22 x M14 at eight different growth stages beginning June 15 (3-leaf stage) and ending July 31 (early tassel). Growth stages at time of treatment are indicated by number of leaves expanded and were further characterized by dissecting plants and weighing individual parts. The principal measurement of plant response was stalk brittleness, which was

quantitatively measured at 2, 5, 11 and 18 days after each treatment. Other observed criteria were yield, morphological responses and effects on seed viability and seedling vigor. The interaction of nitrogen fertilizer and one-half pound per acre of 2,4-D was studied on W22 x M14 plants.

Definite differences in response to 2,4-D were obtained among the four strains. W22 and W22 x M14 were considerably more susceptible than WF9 and WF9 x Os420. The inbreds, particularly W22, showed more susceptibility than the single-crosses in which they were included. Considerably more response followed treatment with the heavier, one-pound-per-acre rate of 2,4-D.

Stalk brittleness was severe only in W22 and W22 x M14 plants treated at the 6- to 11-leaf stages. Brittleness in general was serious 2 days after treatment, even more so at 5 days, less at 11 days, and had practically disappeared at 18 days afterward. Earlier and later applications to these strains and all treatments of WF9 and WF9 x Os420 resulted in little or no brittleness. Nitrogen fertilizer caused an increase in the growth rate of W22 x M14 plants which was associated with greater stalk brittleness after treatment with 2,4-D at the 6- to 10-leaf stages.

A stimulative effect on brace root formation and a resulting interference with the development of the hypodermis were associated with stalk brittleness in treated W22 plants. Breakage was limited to lower nodes that were developing brace roots when the plants were treated, and occurred in the region of brace-root formation just above the sixth or adjacent nodes.

Weak stalks at harvest were found in W22 x M14 and particularly in W22 plants treated at the 6- to 11-leaf stages. Increased stalk weakness due to fertilizer in W22 x M14 was significant in plants

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2 a. B. S. A., University of Florida, Gainesville, Florida, 1943.
M. S. A., *ibid.*, 1949.

treated at the 6- to 14-leaf stages. Since this weakness of mature stalks was correlated with rapid internode elongation in the base of the stalk at time of treatment and with stimulation of brace-root formation, the 2,4-D may have inhibited normal differentiation in these nodes. These observations suggest further that if differentiation was reduced during the period of rapid internode elongation, later differentiation did not repair the damage and the stalk remained weak.

Weak shanks at harvest were found in W22 x M14 plants treated at the 16- and 18-leaf stages when rapid shank elongation occurred. This weakness was slightly but not significantly increased by fertilizer.

Yields were most severely reduced by treatment at the 18-leaf stage (tassel emerging), particularly in W22 and W22 x M14. Lack of grain development at the base of the ears was directly related to these reduced yields. The severity of reductions was related to the concentration of 2,4-D applications. Smaller reductions from earlier treatments were more frequent in W22 plants.

Viability was reduced in seed from self-pollinated W22 and W22 x M14 plants treated at the early tassel stage, and to a lesser extent in W22 from treatment at the 16-leaf stage.

Vigor of seedlings from seed produced by self-pollinated plants was, in general, most seriously affected by treatment at the early tassel stage, but decreased vigor in WF9 was evident from the one pound treatment at practically all stages. Significant reductions in W22 were caused by the one-half pound but not by the one-pound rate of 2,4-D.

Morphological aberrations such as stalk bending, leaf rolling and brace-root abnormalities were most frequent following treatment at the 6- to 11-leaf stages. Stalk bending in plants treated at later growth stages occurred only in higher, still elongating internodes. Bending was most severe from two to five days after treatment but had mostly disappeared after two weeks. Leaf rolling was limited to leaves developed after treatment and was evident for as long as 45 to 50 days. Abnormal brace roots were produced only at nodes normally developing brace roots at that stage of growth.

It may be concluded from the results of this investigation that applications of 2,4-D for weed control in corn should be made before the 6-leaf stage or between the 11- and 16-leaf stages to cause a minimum injury to the crop. Severe stalk brittleness in W22 and W22 x M14 can be expected from treatment with heavy rates of 2,4-D during the 6- to 11-leaf stages. Cultivation or high winds shortly after treatment at these stages may cause many broken stalks and thus a yield reduction. An inhibited seed set and a resulting decreased yield may be expected following treatment between the 16-leaf and the early-tassel stages. Viability may be low in seed produced by W22 and W22 x M14 plants treated at these late growth stages and seedlings from such seed and from seed of treated WF9 plants may show a decreased vigor. WF9 and WF9 x Os420 are comparatively tolerant to 2,4-D, but W22 and W22 x M14 should not be sprayed, particularly during the susceptible growth stages, unless a large yield reduction is expected from heavy weed competition.

DENATURATION OF OVALBUMIN AS REVEALED BY STREAMING ORIENTATION¹

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Denaturation of globular proteins generally leads to configurational changes in

the polypeptide chains. Among the techniques available for the investigation of the change in asymmetry during denaturation, streaming orientation seems particularly suitable. The apparent lengths of the solute particles so determined are not significantly influenced by their axial ratio, or by their degree of hydration. In applying the method to ovalbumin, the orientation of the optic axis of the flow-

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ing solution with respect to the flow-lines was determined over a range in velocity-gradient, and the magnitude of the birefringence measured over the same range. The three-dimensional orientation theory developed by Peterlin and Stuart (3, 4), and Peterlin (2), was applied. The theory was developed on the basis of rigid, ellipsoidal particles, homogeneous in length. Lengths of solute particles were calculated using the solutions of Scheraga, Edsall, and Gadd (5) to the differential-equations for the above three-dimensional orientation case, and the Perrin (1) equation relating rotary-diffusion constant to the dimensions of the particle. The function $\Delta/f c$, which may be taken to represent an apparent intrinsic birefringence of the solute particles, was also calculated using the data of Scheraga, Edsall, and Gadd (5). In this function Δ is the analyser rotation of the Senarmont compensator, f is an orientation factor, and c is the protein concentration.

The experimental work encompasses the denaturation of three-times crystallized ovalbumin by heat (1) at various pH values in the acid region, (2) in the presence of a cationic detergent in the acid region, (3) in the presence of urea, (4) in 85 per cent glycerol solution at various pH values in both the acid and the alkaline region, and (5) in 85 per cent glycerol in the presence of an anionic detergent in the alkaline region. Particular care was taken to avoid conditions of denaturation which would lead to pronounced haziness or to gelation. Likewise, experimental conditions were sought which would lead to a minimum of polydispersity, and the most emphasis is placed on data in which the solute particles appear homogeneous in length. Some of the results are given below.

Solutions containing 0.6-2.4 per cent ovalbumin in glycine-hydrochloric acid buffers at pH 1-4 were denatured by heating at 100°C. for periods of time from 5 to 240 minutes. Measurements of orientation angle and birefringence were made at 25°C. at various gradients after addition of glycerol to a final concentration of 70 per cent. Solutions having solute particles in the range 500-600 Å in length appeared homogeneous, as judged by decreasing apparent length with increasing gradient, and solutions exhibiting greater lengths appeared polydisperse. Increased lengths were obtained with increased time of heating and with increased ovalbumin concentration during heating. Aggregation is an important cause of polydispersity.

Solutions containing 0.8 per cent native, isoelectric ovalbumin in 70 per cent glycerol solution, as well as in 91.5 per cent showed no detectable flow-orientation.

Heat denaturation at 100°C. for 5 minutes in the presence of a cationic detergent, Zephiran, produced apparently homogeneous solute particles around 500-600 Å in length. Presence of the detergent during denaturation resulted in a lesser amount of polydispersity. The magnitude of the birefringence of heat-denatured solutions of ovalbumin containing this detergent was distinctly less than that of ovalbumin solutions denatured in its absence. Detergent added after heating the ovalbumin solution was also bound by the protein, as judged by the reduction of birefringence, but was not effective in reducing length or polydispersity.

Heating for 5½ minutes at 100°C. at pH 8 in veronal-hydrochloric acid buffer containing urea (2-4 M in concentration) resulted in decreased lengths with increased urea concentration. At the limit of the measurements in 4 M urea solution apparently homogeneous solute particles of about 700 Å length were obtained. At pH 2.6, in glycine-hydrochloric acid buffer, heating 5½ minutes at 100°C. in 2 M urea solution resulted in apparently homogeneous solute particles about 600 Å long. The over-all effect of urea in heat denaturation seems to be that of decreasing aggregation.

Denaturation was effected in 0.39 per cent ovalbumin solutions containing 85 per cent glycerol and HCl or NaOH to obtain the desired pH in the range 0.73-11.0. Lengths were measured after 15 minutes heating at 100°C. In the pH range 7.5-11.0 lengths decreased from 1100 to 375 Å. In the acid range lengths of about 300 Å were obtained at pH values 2-3; at pH 0.73 the length was about 1100 and at pH 4 about 700 Å.

Highly aggregated solutions were produced upon heating for 15 minutes at 100°C. and pH 0.93 in 85 per cent glycerol solution. At a lower temperature, 50°, and a shorter heating time, 5 minutes, the solute particles appeared homogeneous of length about 500 Å. Heat denaturation at pH 2.5 in 85 per cent glycerol solution resulted in shorter lengths, 350 Å, than are produced at pH 0.93.

At pH 10.25 heating at 80°C. in 85 per cent glycerol solution yielded solute particles, apparently monodisperse, approximately 450 Å long. Increasing the temperature to 100°C. but otherwise keeping the denaturation conditions the same gave

a limiting length around 450 Å. Aggregation is much less prominent at pH 10.25 than at the other pH values studied.

The anionic detergent, dodecylbenzene sodium sulfonate, is bound even at pH 10.5, as evidenced by the lower birefringence of ovalbumin solutions containing detergent after heating at 100°C. for 5-60 minutes in 85 per cent glycerol solution. Apparently homogeneous solutions with solute particles of lengths 400-475 Å were produced. Polydispersity is lessened in solutions containing the detergent during heating.

The experimental results of this dissertation have been interpreted on the basis that unfolding of ovalbumin molecules to lengths of 350-500 Å occurs during denaturation; the lengths attained depend on the experimental conditions. Aggregation of the unfolded molecules takes place

readily and interpretation of the data are complicated by this factor.

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MECHANISMS OF SELF- AND CROSS-INCOMPATIBILITY IN SWEETCLOVER, *MELILOTUS OFFICINALIS* LAM.¹

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Self- and cross-incompatibility have been found in many of the common forage species. A working knowledge of the mechanisms of self- and cross-incompatibilities in crop plants becomes important in the breeding program. In many breeding plans, inbreeding is required to determine the extent of segregation and in annual and biennial plants it is necessary to maintain germ plasm of selected and tested plants which ultimately may be used in controlled crosses or synthetic strains.

Self-incompatibility in a species could prohibit inbreeding by self-pollination, however it would be of value to insure random cross-pollination among foundation plants maintained in isolated crossing blocks. Cross-incompatibility could limit desired random cross-pollination in this

system of breeding. In most cases, however, cross-incompatibility in forage plants has not limited random cross-pollination.

Natural crossing undoubtedly has played an important part in the evolutionary development of flowering plants. Heterozygosity from cross-pollination tends to mask the expression of deleterious recessives and maintains plant vigor, and provides a wide range in variability necessary for effective selection.

Melilotus officinalis has been shown by several workers to exhibit a high degree of self-incompatibility. Previous work has not revealed the extent of self- and cross-incompatibility in the species. The genetic control of the self- and cross-incompatibility in the species has not been studied as extensively as in red clover and white clover. Research reported to date indicates that the peronate type of incompatibility and/or a complex associate type involving many factors are the genetic mechanisms which control self- and cross-compatibility in sweetclover. The purpose of this study was to estimate the extent of self-incompatibility in this crop and to secure additional evidence concerning the genetic mechanisms in-

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voiced in its expression. A study of the cross-compatibility reactions also was included.

The research work was conducted in the greenhouse during the winter and spring months. Average per cent self-compatibility was determined from 40 flowers on each of four racemes selfed during different periods. Cross-compatibility values were estimated from approximately 25 emasculated flowers crossed in one raceme. The data recorded were expressed as the percentage pod set and transformed to degrees by means of the transformation $p = \sin^2 \theta$ for statistical analysis. Statistical analyses were made on various combinations of percentage and transformed data to compare the two methods of enumeration for analysis.

Self-compatibility relationships were studied in a random sample of Madras sweetclover and in *S.* *S.* *F.* and backcross progenies of the same variety. Cross- and backcross-compatibility among individuals of three *S.* progenies and backcross-compatibility among four *S.* progenies also were included in this study.

M. officinalis, as a species, was found to be predominantly self-incompatible. A random sample of 130 individuals ranged in self-compatibility from 0.0 to 69.2 per cent with a mean of 18.2 per cent. The distribution for self-compatibility was continuous and positively skewed toward low self-compatibility.

Seven *S.* progenies segregated widely for self-compatibility irrespective of the self-compatibility of their parental *S.* clones. These results indicated that all clones studied were heterozygous for genes conditioning self-compatibility. Some self-incompatible individuals were found in all *S.* progenies indicating that all clones carried genes conditioning self-incompatibility. *S.* progenies from high-fertility *S.* clones segregated in a wider range in self-compatibility than did *S.* progenies derived from low-fertility *S.* clones. This suggested that low- and high-fertility *S.* clones differed in their genes conditioning higher levels of self-compatibility.

The distribution for self-compatibility in *S.* progenies derived from low-fertility *S.* clones were positively skewed toward low self-compatibility whereas the distributions for self-compatibility in *S.* progenies from high-fertility *S.* clones were bimodal and negatively skewed showing dominance toward high self-compatibility. Significant differences for self-compatibility were found among plants within all *S.* progenies.

Nineteen out of 19 *S.* progenies segregated significantly for self-compatibility. *S.* progenies derived from low-fertility *S.* plants segregated less widely for self-compatibility than did *S.* progenies from high-fertility *S.* plants. In the same manner *S.* progenies from high-fertility *S.* clones gave wider segregation for self-compatibility than did *S.* progenies from low-fertility *S.* clones. A highly significant correlation coefficient of .47 was found between the self-compatibility of all parents and their inbred-progenies.

The mean self-compatibility of *F* crosses and backcrosses exceeded the self-compatibility of the parents in crosses among low-fertility plants but was lower than the parents in crosses among high-fertility plants. Significant differences for self-compatibility were found among plants within all crosses.

Intra-progeny crosses made in three groups of *S.* progenies differing widely in average self-compatibility to test the hypothesis of an oppositional type of incompatibility in *M. officinalis* revealed that such a system was operating in the populations studied, especially among the low-fertility individuals. Deviations from this system suggested that various self-fertility modifiers were responsible for the higher degrees of self-compatibility. On the basis of the self- and cross-compatibility relationships within *S.* progenies it was proposed that compatibility in low-fertility *S.* clones was conditioned by one factor pair of the personate type *S.S.*, and one self-fertility factor pair designated as *Aa*. It was further proposed that compatibility in high-fertility *S.* clones was conditioned by one factor pair of the personate type *S.S.*, and two self-fertility factor pairs designated as *AaBb* to account for their higher level of self-compatibility. This proposed associate-type genetic mechanism explained reasonably well the results obtained. Modifications of the personate type of sterility are quite common in other herbaceous species. This suggests that the proposed modification of the personate type of sterility could be the mechanism conditioning self- and cross-compatibility in this population.

Significant periodic differences in self-compatibility within *S.* progenies indicated that self-compatibility increased later in the flowering season or that environmental conditions in the greenhouse were more favorable for seed setting.

A highly significant correlation coefficient of .65 was found between the self-compatibility of the same *S.* plants in

four groups of S_1 progenies selfed during two different seasons.

The transformation of percentage data for analysis did not change the statistical conclusions that would have been made had the percentage data been used without transformation. The rather consistently lower error variance obtained with transformed data may make it possible to

obtain significant treatment comparisons when such differences could not be measured by the original percentage values.

There was no indication that the incompatibility exhibited by *M. officinalis* would prohibit inbreeding, crossing, or random recombination of individuals, consequently these breeding systems could be utilized in any well planned improvement program.

PROPERTIES AND CLASSIFICATION OF THE PAHA LOESS-DERIVED SOILS IN NORTHEASTERN IOWA¹

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A field and laboratory study was made of the paha and the soils occurring on the paha in the Iowan glacial drift region of northeast Iowa.

Field studies indicated that paha were considerable in number and occurred in most counties within the Carrington-Clyde soil association. The paha were found to consist of local accumulations of poorly-sorted loess overlying pre-Iowan nuclei which usually consisted of Kansan till. A cross section and elevations of the paha in relation to the Iowan drift plain revealed the height of the pre-Iowan nuclei to be somewhat higher than adjacent loess-free prominences which were completely covered with Iowan till.

The morphology of soils on the surface of the pre-Iowan nuclei now covered by paha loess, indicates the presence of soils and an environment responsible for these soils probably little different from that of today. The lack of any fresh till or glacial materials over the surface of the pre-Iowan nuclei is taken as evidence that the Iowan glacier never overrode the prominences which served as nuclei of the paha. Where the Iowan glacier did override the prominence, it is believed to have obliterated the vegetation and hence did not provide a lodgement for the loess.

The morphology of the soils on the paha indicate that additional soil series should

be recognized within the Carrington-Clyde soil association area. The soils of the paha resemble soils of the Tama, Monona, Downs, Fayette and Ida series developed from well-sorted loess. A soil survey of a paha revealed the influence locally of vegetation and topography on soil development.

Physical studies of the soils on the paha showed them to differ in several respects from presently established series. In general, the results of mechanical analyses showed that they were much more poorly sorted than soils developed in blanket loess such as Tama and Fayette. Volume weight studies showed an irregular but general trend toward increasing volume weight with profile depth. Aeration and total porosity showed an irregular but general decrease with profile depth whereas soils from blanket loess showed a uniform decrease in aeration and total porosity and increase in volume weight with depth. Permeability was very irregular throughout the profile but tended to be high in the surface horizons and to decrease with depth.

Results of some chemical determinations showed the soils of the paha to be more similar chemically to soils of the Iowan glacial drift than loess soils in the same region. Comparison of two soils of the paha with their morphological analogues revealed some differences in exchangeable hydrogen, calcium, magnesium and calcium to magnesium ratios. The field and laboratory data from the study show the need for new soil series for the soils of the paha. The two factors of soil formation which differentiate the paha soils from the surrounding soils are parent material and vegetation, the former being dominant.

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ANTHRACNOSE FUNGI ON SYCAMORE AND OAK IN IOWA¹

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Anthracnose diseases of white oak and sycamore cause severe defoliation in early spring and fall when climatic conditions are favorable, furthermore, they cause extensive twig blight and destruction of the growing points. The extent to which the disease damages the tree by reducing the radial as well as the terminal growth is not generally recognized since a property owner usually sees only the fallen leaves on his lawn.

Anthracnose fungi isolated from infected oak and sycamore were divided into two rather well-defined groups. The sycamore group included conidial isolates from sycamore (*Platanus occidentalis* L.), white oak (*Quercus alba* L.) and bur oak (*Quercus macrocarpa* Michx.), in addition to the sexual stages produced on overwintered leaves of white oak and sycamore. The conidia from ascospores and naturally infected tissue were indistinguishable, regardless of source. The ascogenous stage from white oak and sycamore differed little, except for perithecial beak length. Conidial isolates from sycamore were capable of infecting white oak and sycamore. The evidence indicated all these isolates are included in *Gnomonia veneta* (Speg. & Sacc.) Klebahn.

The oak group included conidial isolates from red oak (*Quercus borealis* Michx.), white oak, American elm (*Ulmus americana* L.) and black walnut (*Juglans nigra* L.). The conidia from this group were larger than those from the sycamore group and were more uniformly shaped. The cultural characteristics of the two groups were different. Conidia of the oak group were never obtained from single ascospore cultures. Conidial isolates from white oak (oak group) were capable of infecting both white oak and sycamore. Although there was some evidence the oak group was closely related to *Gnomonia veneta*,

it was proposed these isolates be referred to as *Gloeosporium quercinum* West until proof of their identity can be more definitely established.

Isolates from both groups grew on natural media such as potato-dextrose or yeast agar, but did not grow on such synthetic media as Czapek's or Elliott's agar. A synthetic medium fortified with certain vitamins was found to support growth.

All isolates of the oak group tested gave the same response by exhibiting a complete deficiency for inositol, and a partial deficiency for thiamin. When a representative isolate of this group was supplied with the necessary vitamins and an organic source of nitrogen, such as vitamin-free casein hydrolysate, more growth occurred than when only inorganic nitrogen was present in the basal medium. The rate of growth was more than doubled when these isolates were aerated by shake culture. Isolate B-3-3 of the oak group was sensitive to 0.1 ppm. of inositol.

Within isolates of the sycamore group two strains were distinguished by their growth factor requirements: (1) Isolates from sycamore showed nearly a complete deficiency for biotin and partial deficiencies for thiamin and inositol, however, there was some evidence inositol could partially replace biotin. When biotin and thiamin were added to the basal medium good growth occurred. The fact that these isolates grew when biotin alone was added to the basal medium distinguished them from the oak group in which growth occurred only when inositol was added. (2) Isolates from white oak (sycamore group) exhibited a different response. They grew without the addition of vitamins to the basal medium, and grew better, but about equally well on inositol and thiamin, or biotin and thiamin.

Thiamin was found to increase the sporulation of all isolates tested. Six times as much sporulation was recorded when thiamin, biotin and inositol were added to the basal medium as was recorded when all supplements, except thiamin, were added.

Oleic and linoleic acid emulsions, and sodium oleate solutions (adjusted to pH 7.5) stimulated the germination of spores

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from isolates of both the sycamore and the oak groups. These materials also sharply increased the respiratory rate of a representative isolate of the oak group.

The optimum hydrogen-ion concentration for germination of spores from a representative isolate of the oak group was pH 4 to 5.

When droplets of spore suspensions, from an isolate of the oak group, were incubated for 24 hours on glass slides in relative humidities from 100 to 95 per cent, maximum germination occurred at 97 per cent.

One-year-old white oak seedlings were successfully inoculated with isolates from the oak and sycamore groups by using spore germination stimulants and a gradual reduction of the relative humidity in the moist chambers.

It was shown for the first time that *Gnomonia veneta* was able to grow from

infected leaves to healthy twigs and cause twig blight. Likewise, it was shown that the fungus is able to grow from infected twigs into healthy leaves and cause leaf blight.

In a replicated test on sycamores in 1950, *Gnomonia veneta* was effectively controlled by four spray applications. A significant difference was found between the checks and the treatments, but differences between treatments were not significant. However, on the basis of two years' results Bordeaux mixture appeared to be the best material for controlling sycamore anthracnose. In a test with phenylmercuri-triethanol ammonium lactate on large sycamore trees, the combination of a dormant spray and a broken bud spray was most effective in controlling the disease. This chemical caused some injury to leaf surfaces.

PART I

CORRELATION OF POLAROGRAPHIC REDUCTION POTENTIALS OF ORGANIC CARBONYL COMPOUNDS WITH REACTIVITY

PART II

REACTIVITY OF FURANS BEARING ELECTRON-ATTRACTING SUBSTITUENTS¹

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Department of Chemistry

PART I

CORRELATION OF POLAROGRAPHIC REDUCTION POTENTIALS OF ORGANIC CARBONYL COMPOUNDS WITH REACTIVITY

Early in the polarographic study of organic compounds it was recognized that the potential at which a given functional group is reduced depends on the nature

of a second substituent in the molecule. Shikata³ observed that the reduction potentials of aromatic nitro compounds were shifted to more positive values by the introduction of electronegative substituents elsewhere in the molecule and that electron-donating groups have the opposite effect. The primary objective of this research was to attempt a quantitative correlation of the substituent effects in this reaction with those observed in other chemical reactions. Such a comparison was carried out conveniently by utilizing two standard empirical methods for correlating structure reactivity.

The most widely used of these methods is that of Hammett⁴ who has shown that for many reactions on side chains of meta- and para-substituted benzene derivatives the rate or equilibrium constants can be related by the equation

- 1 a. Chairman of Committee, George S. Hammond, Assistant Professor, Dept. of Chemistry, Industrial Science Research Institute, b. Doctoral Thesis No. 1126. Submitted December 8, 1950.
- 2 a. A. B., Kansas State Teachers College, Pittsburg, Kansas, 1942. b. Fellow, Industrial Science Research Institute.
- 3 M. Shikata and I. Tachi Coll. Czech. Chem. Commun., 10, 368 (1938).
- 4 L. P. Hammett, *Physical Organic Chemistry*. (New York: McGraw-Hill Book Company, Inc., 1940), p. 186.

$$\log k - \log k^0 = \rho\sigma, \quad (1)$$

where k and k^0 are the rate or ionization constants for the substituted and unsubstituted compounds respectively, ρ , a constant for a particular reaction, and σ , a constant for the substituent. By making the assumption that the addition of an electron or electrons to the reducible group is a reversible step which is followed by irreversible steps whose rates do not vary appreciably with changes in substitution, it is readily shown that if the first step fits the Hammett treatment, the following relationship should hold:

$$E_{\frac{1}{2}} - E^0_{\frac{1}{2}} = \rho'\sigma. \quad (2)$$

In this equation $E_{\frac{1}{2}}$ and $E^0_{\frac{1}{2}}$ are the half-wave potentials for the substituted and unsubstituted compounds respectively when both are determined under the same

$$\text{conditions, and } \rho' = \frac{2.303RT}{nF} \rho.$$

Another method of correlation is that of Hixon and Johns⁵ in which the free ener-

gies of a series of reactions involving a given functional group are related to a property, called the electron-sharing ability, of the substituent groups as follows:

$$-\Delta F = kRT(e^{ax-b} - c), \quad (3)$$

in which K , a , b , and c are constants and x is the electron-sharing ability. The two methods should be equivalent in the range of substituent variation which has been investigated here. The relation between the electron-sharing ability, x , and Hammett's σ constant is:

$$e^{0.5x} = 8.06 - 13.51\sigma. \quad (4)$$

To make this correlation the half-wave potentials of a series of substituted benzaldehydes and acetophenones were determined in a solvent consisting of 33.3 per cent ethyl alcohol and 66.7 per cent 0.2 M MacIlvaine buffer mixture of pH 7. All measurements were made with a Sargent Model XXI polarograph. The dropping mercury electrode under a head of 65.5 centimeters of mercury had a drop time, t , of 4.02 seconds and the mass of mercury flowing was 1.453 milligrams/second determined with an open circuit

5 R. M. Hixon and I. B. Johns, *J. Amer. Chem. Soc.*, 49, 1786 (1927).

TABLE 1

HALF-WAVE POTENTIALS VS. S. C. E. AND DIFFUSION CURRENTS OF SUBSTITUTED BENZALDEHYDES IN MACILVAINE'S BUFFER SOLUTION OF pH 7, 33.3 PER CENT ETHYL ALCOHOL

Substituent	$E_{1/2}$	i_d Microamps. \times liter/millimole
p-Hydroxy.....	-1.567	3.98
p-Methoxy.....	-1.509	5.08
p-Methyl*.....	-1.384	5.13
m-Methyl*.....	-1.407	4.93
None.....	-1.463	5.23
p-Chloro.....	-1.392	5.35
m-Chloro.....	-1.317	3.99
m-Nitro† (a).....	-0.616	8.50
(b).....	-1.445	3.74
p-Nitro† (a).....	-0.523	8.65
(b).....	-1.407	7.78
(c).....	-1.575	7.78

* The polarograms for these compounds indicated slight maxima.

† Corrected for IR drop.

a —first wave; b —second wave; c —third wave.

TABLE 2
 HALF-WAVE POTENTIALS VS. S. C. E. AND DIFFUSION CURRENTS OF SUBSTITUTED BENZALDEHYDES
 IN MACILVAINE'S BUFFER SOLUTION OF pH 7, 33.3 PER CENT ETHYL ALCOHOL

Substituent	$E_{1/2}$	i_d Microamps. x liter/millimole
p-Amino	-1.720	4.38
p-Hydroxy	-1.704	2.12
p-Methoxy	-1.667	2.28
p-Methyl (a)	-1.651	1.86
(b)	-1.804	1.92
m-Amino (c)	-1.549	4.63
None (a)	-1.582	2.72
(b)	-1.716	2.29
p-Chloro (a)	-1.517	2.86
(b)	-1.660	2.10
p-Bromo (a)	-1.463	3.40
(b)	-1.601	1.78
m-Nitro* (a)	-0.625	9.14
(b)	-0.625	4.77

* Corrected for IR drop.

a — first wave; b — second wave; c — combined waves.

in a solvent and supporting electrolyte the same as that used in making polarographic determinations. The value of $m^{2/3}t^{1/6}$ is 1.618 $\text{mg.}^{2/3} \text{ sec.}^{-1/2}$. The results obtained are given in Tables 1 and 2.

A plot of the half-wave potentials against the σ constant gave a straight line for both the aldehydes and ketones with a slope, ρ' , of 0.325. By plotting other values obtained from the literature⁶ it was found that for the first wave the value of ρ' is independent of the hydrogen ion concentration. Neither the nitro nor the amino group gave an adequate fit when they were substituted in either the meta or para positions. An analysis of the diffusion currents showed that the failure with the nitro compounds is due to the fact that this group is reduced at a more positive potential than that at which the carbonyl functions reduce. No really satisfactory explanation was found for the behavior of the amino compounds but it is believed that it may be due to a relatively high concentration of hydrogen ions

at the electrode surface. This would result in the conversion of the amines to their conjugate acids and increase the apparent reduction potential.

As was expected, a plot of the half-wave potentials against the electron-sharing ability of the substituents also gave a smooth curve. The half-wave potential can be expressed by the equation

$$E_{1/2} = K' (e^{ax} - c), \quad (5)$$

in which K' , a , and c are constants.

The good agreement obtained with the Hammett treatment and with that of Hixon and Johns indicates that the assumptions made as to the electrode reaction are essentially correct.

The polarographic reduction of organomercuric iodides was attempted but maxima rendered the curves uninterpretable. The compounds p-chlorophenylmercuric iodide, 5-methyl-2-iodomercurifuran and 5,5'-dimethyl-2,2'-difurylmercury with melting points of 242-244°, 96° (with decomposition) and 103°, which have not been previously reported, were prepared.

6 J. Baker, W. Davies, and M. Hemming, *J. Chem. Soc.*, 1940, 692.

TABLE 3

MOLAR EXTINCTION COEFFICIENTS OF α -ACETYL-FURAN AND DERIVATIVES AT THE WAVE LENGTH OF MAXIMUM ABSORPTION

Substituent	Melting point	Wave length of maximum absorption in millimicrons	Molar extinction coefficient
α -Acetylfuran		226 270	2,365 13,500
Di- α -furoylmethane	70.5-72.0°	284 365 380*	8,690 28,600 24,850
Tri- α -furoylmethane	193	225 281 370 382*	8,470 32,800 10,520 10,090
α -Acetofuranoxime	103	265	15,000
Di- α -furoylmethanedioxime	176-178	264	27,400
3,5-Di- α -furoylisoxazole	112	253 292	15,300 23,600
Tri- α -furoylmethane†		282 370	23,150 17,650
Di- α -furoylmethane†		276 375	10,300 29,300
p-Toluenesulfonyl-2-acetofuranoxime	76	222 271 274	14,570 16,050 16,200‡
Ammonium p-toluenesulfonate		222 256 262 268	10,680 210 249 182
Hexen-2-dion-4,5-diethylacetal-1		293	86
Hexen-2-dion-4,5-aldoxime	235	233 333	11,700 11,290

* Shoulder.

† Determined in 0.06 N sodium hydroxide.

‡ This value is undoubtedly low because this compound dissolves with difficulty in 95% ethyl alcohol and in this solvent its rate of decomposition is quite rapid. A value of 16,800 was found when absolute ethanol was used.

PART II

REACTIVITY OF FURANS BEARING ELECTRON-ATTRACTING SUBSTITUENTS

Vargha, *et al.*⁷ have shown that p-toluenesulfonyl-2-acetofuranoxime in the presence of ethyl alcohol undergoes scission of the furan nucleus to give hexen-2-dion-4,5-diethylacetal-1 and ammonium p-toluenesulfonate. To gain a better in-

sight into the mechanism of furan ring scissions some kinetic studies were made on this reaction.

An attempt to prepare α -acetylfuran, an intermediate used in the preparation of the above tosylate, by reacting α -furoyl chloride with dimethyl cadmium, was accompanied by considerable side reaction. This side reaction proved to be acylation of the methyl ketone giving di- α -furoylmethane and tri- α -furoylmethane. In one run the yields of these compounds based on the acid chloride used were 6 and 7 per cent respectively. These compounds have not

7 L. Vargha, J. Ramonczai and P. Bite, *J. Amer. Chem. Soc.*, 70, 371 (1948).

been previously reported and their structure proof depends on an unambiguous synthesis. Further proof of their structure was obtained by determination of neutral equivalents, preparation of derivatives, quantitative iodoform reaction and ultraviolet absorption spectra. The pertinent data obtained are given in Table 3.

In attempting to prepare the oxime and isoxazole of tri- α -furoylmethane it was found that one furoyl group was replaced by hydrogen resulting in identically the same derivatives as those obtained for di- α -furoylmethane.

The absorption spectra of p-toluenesulfonyl chloride and the products of its alcoholic decomposition are also listed in Table 1. Kinetic rates were followed by periodically removing samples from the reaction mixture and immediately measuring the optical density at 274 millimicrons. At this wave length p-toluenesulfonyl-2-acetofuranoxime has maximum absorption and the products both show minima.

The first-order rate law was obeyed up to 95 per cent completion of the reaction in 95 per cent ethanol and was also

obeyed in absolute ethanol. The rate constants were $1.36 \times 10^{-4} \text{ sec.}^{-1}$ and $5.52 \times 10^{-5} \text{ sec.}^{-1}$ respectively. In 0.1 M sodium perchlorate a first-order rate plot was not obtained. This was probably due to failure of the analytical method rather than to a change in the reaction order as the absorption spectrum of the reaction mixtures after two days indicated that different products had formed. An estimated rate, assuming that the first-order rate law was obeyed for the initial reaction, was $1.75 \times 10^{-4} \text{ sec.}^{-1}$.

The fact that the reaction rate only doubled when the water concentration was increased by a large factor indicates that water does not take part in the rate-determining step and that the observed change in rate is probably due to the change in the dielectric constant. The rate-controlling step then must be ionization of the p-toluenesulfonyl-2-acetofuranoxime. The positive ion produced then undergoes simultaneous attack by solvent and ring opening forming an unstable imide which subsequently reacts further with the solvent to form an unstable ketal.

SUBSURFACE DRAINAGE WITH SMALL PERFORATED FLEXIBLE TUBES IN MOLE DRAINS¹

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The purpose of this investigation was to find a method of subsurface drainage which was more economical than tile drainage. There are many areas in Iowa and other states where the high cost of tile drainage makes this practice questionable from an economical standpoint. Mole drainage, which is more economical than tile drainage, has been studied in Iowa and other states. It has not been very successful in the north central states and at best is considered a temporary practice. Methods of stabilizing mole channels with metal tubes and by extruding a porous concrete pipe have been investigated in Germany.

In 1947 it was learned that thermoplastic (polyethylene) tubing was being produced commercially and that this tubing possessed physical and chemical properties which indicated that it would be suitable for mole drainage stabilization, as well as economical in cost. Except for a limited study of this method by the New England Division of the U. S. Corps of Engineers in 1946, no previous investigations have been made. Stabilizing mole drains with flexible plastic tubes is a broad problem and because of this only certain aspects were considered.

The effect of the number and size of perforations on the flow into subsurface drain tubes was determined by theoretical analysis and verified by spot-checking with an electric analogue. Theoretical calculations were made for tube diameters of 2, 4, 6, and 12 inches; for 2, 4, and 8 rows of holes not to exceed 50 perforations per foot; for 1/4- and 1/2-inch diameter perforations; and for depths of 1, 2, 4, and 8 feet in all possible combinations.

The flow into perforated tubes was 62 per cent or less of the flow into a completely porous drain depending on the particular combination considered. The effect of the perforations was expressed as the ratio of the flow into perforated tubes to the flow into completely porous drain tubes. The inflow into 5-inch tile drains at various crack spacings was compared to the flow into perforated drain tubes. Greater flow was obtained by placing a row of perforations on top of the tube than on the bottom.

The effect of deviations from true grade on the performance of small perforated drain tubes was studied in the laboratory. One-inch copper tubes 10 feet in length having the desired curvature were placed in a wooden tank which was filled with sand or soil. At the upper end of the tank the head required to move water through the drain tubes was measured for slopes up to 4 per cent. This head represented the height of the water table; that is, a high head indicated lack of drainage. The head increased with greater numbers of deviations from true grade and with greater amounts of deviations. The head increased with larger amounts of entrapped air and as the slope in the tubes decreased. With tubes larger than 1 inch in diameter, under field conditions the effect of a few small deviations from true grade was not considered serious from the standpoint of reduced drainage, but may be undesirable because of silt accumulation.

Field investigations were conducted on the stability of perforated polyethylene drain tubes in mole drains. Tubing from 1 to 4 inches in diameter was used with wall thicknesses varying from 0.015 to 0.156 inch. Drains were installed in several sizes of mole channels and in different soil areas of Iowa. Since the tubes had been in the soil from 1 to less than 3 years, the results were not conclusive. The stability of perforated flexible tubes in mole drains decreased as the wall thickness was reduced. Polyethylene in soil showed no visible evidence of deterioration after 32 months.

A comparison was made between the

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- 2 a. B. S., Kansas State College, Manhattan, Kansas, 1942.
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cost of tile drains and plastic tube drains for depths of 3 and 4 feet. Considering stability, capacity, and cost, drain tubes 1½ and 2 inches in diameter were considered most practical. Drain tubes 1½ inches in diameter with .040-inch wall thickness can be installed for about one-half the cost for 5-inch tile drains. Small

plastic tube drains appeared to be most applicable in the drainage of hillside seeps or other wet areas on sloping land and in soils with impermeable subsoils which require drains at narrow spacing. In general tile drains would be required for mains and submains while plastic tubes would be suitable for laterals.

TECHNIQUES FOR ESTIMATING COEFFICIENT OF CORRELATION FROM A FOURFOLD TABLE¹

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A tetrachoric coefficient of correlation is computed from data in which two traits or characteristics have each been reduced artificially to two dichotomies either by choice or because of the lack of precise methods of classification. Under appropriate conditions, it gives a coefficient that is numerically equivalent to a Pearson product-moment coefficient of correlation and may be regarded as an approximation to it. The basic assumptions that tetrachoric r requires are that both traits or characteristics are continuously variable, normally distributed, and linearly related. The general formula for the computation of a tetrachoric correlation coefficient was developed by Karl Pearson in 1905.

Several methods have been used which would simplify the calculation of a tetrachoric r . One of the more recent methods which could be used was the publication of charts by Thurstone. Since these charts are now out of print, there was a need of developing tables which would replace them with a method which would be convenient and time saving.

The proposed method of correction factors was determined by the use of the formula, $r_t = \sin (ad - bc)/N^2 \cdot 360$, where a , b , c and d are the cells of the fourfold table used in the calculation of tetrachoric r . This formula can be used if the two related traits are divided at the medians of each distribution. Therefore, it was necessary to determine correction factors that

would transform the value of $(ad - bc)/N^2$, when the dichotomies are not divided at the medians, to a value when the dichotomies are divided at the median and the preceding \sin formula can be used.

The correction factors were determined from a master scattergram which had a correlation of 0.86399 and a total of 400 cases. A regression equation was developed from the values of $(ad - bc)/N^2$ from the fourfold tables obtained from the master scattergram. With the use of this regression equation, correction factors were found which would correct the value of $(ad - bc)/N^2$ for any division of the dichotomies to a value of $(ad - bc)/N^2$ when the dichotomies were divided at the medians.

These correction factors were tested against three other methods of computing tetrachoric r when fourfold tables are chosen from various scattergrams. These three methods were: the first two terms of the general formula of tetrachoric r , the first ten terms of the general formula and Thurstone's charts. The product-moment coefficient of correlation of the scattergrams was used as a criterion. On an average, the correction factor method compares favorably with the ten-term method and with Thurstone's charts, although the correction factor method had a slight downward bias as compared with the product-moment correlation.

The variabilities between the tetrachoric correlation coefficients for each of the four methods and the product-moment correlation coefficients were computed. The correction factor method was the least variable of the four methods considered, with a variability of 1.6714. The next least variable method was the ten-term method with a variability of 1.8746, while the

- 1 a. Chairman of Committee, James E. Wert, Professor, Dept. of Vocational Education, Agricultural Experiment Station.
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- 2 a. B. S., Iowa State College, Ames, Iowa, 1944.
M. S., *ibid.*, 1947.
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variability of Thurstone's charts was 1.9172.

The relationship between each tetrachoric correlation method and the product-moment method was calculated. The ten-term method and the correction-factor method had approximately the same coefficient of correlation when correlated with the product-moment correlation method. The correlations were 0.9545 and 0.9540, respectively.

When the amount of time used to calculate a tetrachoric r for each of the four methods was used as a criterion, the correction factor method was the least time consuming. The correction factor method needed three minutes of time, while all of the other methods needed six

minutes or more. The ten-term method needed the most time, which was in the excess of 20 minutes.

The proposed method of correction factors is the most satisfactory method of the methods considered for use in calculating a tetrachoric r . The correction factor method is least variable and the most feasible of the four methods. It is not based on the function of the size of the correlation coefficient as are some of the methods.

Further research is needed whereby correction factors can be developed which will eliminate the slight downward bias which is present in the proposed correction factors in this study.

CHROMATOGRAPHIC SEPARATIONS OF SOIL ORGANIC PHOSPHORUS COMPOUNDS¹

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The occurrence of phytin and its derivatives in soil was investigated. The acidic nature of these compounds suggested that they could be separated from unknown mixtures by means of anion exchange resins in columns. A chromatographic method was developed that was capable of resolving mixtures of sodium phytate and its enzymatically produced derivatives. It was found that washing of a weak-base anion exchanger, initially in its sulfate form, with hydrochloric acid of increasing strength, resulted in the resolution of mixtures of adsorbed inositol phosphates. A 1.25 x 24 cm. bed of resin in a column, having not more than the upper one-fourth of the bed saturated with the mixture to be resolved, was washed at a rate of 32 ml. per hour with hydrochloric acid. During the run the acid strength was increased from 0.1 N to about 1 N . Each hour's effluent was collected as a separate fraction and its

content of organic phosphorus determined.

From a mixture of sodium phytate and derivatives nine organic compounds were separated in sufficient quantities to permit determination of their inositol/phosphorus ratios. Phosphorus was determined colorimetrically, and inositol determined by means of a biological assay, employing the yeast *Saccharomyces carlsbergensis* as the test organism. While the observed ratios were variable, the determinations were replicated sufficiently that the number of phosphorus atoms per molecule of inositol was considered to have been determined to within one atom of the true value in all cases. The identity of the nine separated compounds was tentatively established.

Four Iowa soils—a Harpster, a Webster, a Clarion, and an unnamed acid forest soil—were studied. An untreated sample of each, and one to which a mixture of inositol phosphates had been added, were extracted by a method thought to be specific for phytin. The extracts were then examined chromatographically.

Only 25 to 50 per cent of the organic phosphorus extracted from the soil as phytin was eluted concurrently with known inositol phosphates, and generally less than half of that amount appeared to be the hexaphosphate. The mixing of inositol phosphates with the soil extract

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- b. Doctoral Thesis No. 1161. Submitted April 20, 1951.
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did not result in the appearance of more peaks in the elution curve than were evident in the curves from either component of the mixture tested separately. The nature of the material behaving differently from inositol phosphates was not investigated.

Samples of the Clarion loam and forest soil were amended with radioactive phosphorus, dextrose and ammonium nitrate, and were incubated in a moist condition for 30 days at room temperature. A mixture of inositol phosphates was then added, and the phytin extracted immediately. When the components of the extract were separated chromatographically, activity in the eluate was found to follow the elu-

tion curve for organic phosphorus over that portion of the run during which known inositol penta- and hexaphosphates were being eluted.

The data show that the salts of inositol pentaphosphoric and hexaphosphoric acids are common constituents of soil organic matter. The low content of inositol phosphates in the soil extracts indicates that the amounts of phytin present in soils may be considerably less than have been previously estimated. The incorporation, during incubation, of radioactive phosphorus into materials inseparable chromatographically from inositol hexaphosphate strongly suggests the microbial synthesis of phytin in the soil.

A CRITICAL SCALE STUDY OF TWO POPULATIONS OF BLUEGILL AND GREEN SUNFISH¹

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Special attention in this study of bluegills (*Lepomis m. macrochirus*) taken from McFarland's Pond, Story County, Iowa, from June, 1949, to July, 1950, and of bluegills and green sunfish (*Lepomis cyanellus*) collected from Little Wall Lake, Hamilton County, Iowa, from June, 1948, to April, 1950, was directed toward an evaluation of certain problems associated with the reading of the life history of a fish from its scales.

McFarland's Pond is a relatively rich artificial pond constructed in the fall of 1946 with a surface area of 7 acres and a maximum depth of 23 feet. Thermal stratification and subsurface stagnation were such that dissolved oxygen became depleted at depths of 2 meters or more during late winter and summer months and limited the normal activities of fish to the shallower strata. Fish entered the oxygen depleted levels but died if they were detained for 2 hours or more. Little Wall Lake is a shallow eutrophic lake of approximately 230 acres, an estimated

75 per cent of which was between 5 and 7 feet deep in 1948. The lake was dry as recently as 1935-42 and experienced winterkill conditions in February of 1949 and 1950 that eliminated the bluegill population and severely reduced the number of green sunfish in the earlier year and presumably killed the remaining sunfish in 1950.

General validity of the scale method and yearly establishment of a true annulus was believed confirmed for the bluegills and green sunfish by the following observations: within reasonable limits, fish assigned to the same age group possessed similar lengths; annuli were formed at approximately the same time in each season studied; observed new growth beyond the annulus progressively increased with time during the growing season and each individual year class was found to have its own seasonal growth characteristics; factors influencing the growth of the fish were consistently recorded on the scales; winterkill victims had not formed a current annulus when death occurred in February; no age-group-III bluegills could have been present in McFarland's Pond in 1949 and none were found to exhibit three true annuli in that year.

Curvilinear regressions were found to represent the body-scale relationships of bluegills and green sunfish better than

1 a. Chairman of Committee, Kenneth Carlander, Associate Professor, Dept. of Zoology and Entomology, Industrial Science Research Institute.

b. Doctoral Thesis No. 1132. Submitted December 12, 1950.

2 a. B. S., Iowa State College, Ames, Iowa, 1946.

M. S., *ibid.*, 1947.

b. Assistant Professor, Dept. of Zoology and Entomology; Collaborator, Industrial Science Research Institute.

linear regressions, but the increases in accuracy resulting from such curvilinear corrections were so small as to have little practical application. Anterior-scale radius measurements from Little Wall Lake bluegills were relatively larger than those of bluegills of similar sizes from McFarland's Pond.

Annulus formation began in many McFarland's Pond bluegills in early May of 1949 and April of 1950. All green sunfish and bluegills collected by early- or mid-June had completed annuli for the current year. Growth appeared to be most rapid in bluegills and green sunfish during June, but in some instances bluegills continued to grow slowly until October and green sunfish at least until early August. Growth during the first year of life of McFarland's bluegills was less in 1947 than in 1948 and 1949, probably due to the lack of food for small fish in the new pond or to a shortened growing season. The growth increments of the 1947- and 1948-year-class bluegills from the same pond were so low in 1949 as to indicate severe stunting, although young-of-the-year still showed good growth. Little Wall Lake bluegills grew very rapidly in 1947, but growth in other years was retarded. Green sunfish in the 1946 (dominate) year class grew at a slower rate throughout life than other individuals. Growth of all green sunfish was reduced in 1948 but winterkill survivors grew at an accelerated rate in 1949. Male bluegills and male green sunfish showed a tendency to grow faster than females. Slower-growing green sunfish apparently withstood winterkill conditions better than faster-growing specimens.

A linear regression gave a slightly better mathematical representation of the relationship between standard- and fork-length measurements of bluegills than a curvilinear regression. The tails of Little Wall Lake bluegills were longer in relation to body length than were the tails of McFarland's bluegills. Tails of green sunfish grew at a slower rate than the body as the individuals increased in length.

The weight of bluegills and green sunfish increased at a rate slightly in excess of the cube of the length. Coefficient of condition for both species increased somewhat irregularly as length increased. Little Wall Lake bluegills were heavier for their length than bluegills from McFarland's Pond.

False annuli were found at varying rates of occurrence, but, although many of the McFarland's Pond bluegills produced accessory marks that could have been considered spawning marks, there appeared to be no consistent relationship between environmental factors, sexual development, or rate of growth and the formation of false rings on the scales. Certain year classes of bluegills consistently produced a supernumerary check between the scale focus and the first annulus but these conditions were not necessarily the same for the same year class in different bodies of water. A few criteria helpful in recognizing false annuli are: (a) a scale mark preceded by a zone of relatively widely separated circuli and followed by closely spaced circuli is usually not a true year mark; (b) if a mark lacks continuity or definition on any portion of the scale, examination of adjacent scales will usually reveal the character of the mark because false rings frequently do not appear on all scales while true annuli generally do; (c) particularly dark marks on a scale should be examined very carefully for a possible false nature; (d) lack of extensive anastomosis of circuli with the mark and little extension of the mark across the posterior field of the scale does not necessarily identify a false annulus but the lack of such characters should alert the worker for other evidence of a possible false mark; (e) if false marks indistinguishable from true annuli are suspected of being present, a comparison of the scale with a series of scales from other fish in the same size group will frequently reveal the marks that do not coincide with the true annuli in the year-class, growth pattern.

PUTREFACTIVE ANAEROBIC SPORES IN MEAT¹

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Department of Bacteriology

The present work was intended to extend the knowledge regarding the numbers and types of putrefactive anaerobic spores occurring in meat. Previous investigations indicated that the numbers of spores in pork were low. This study included the incidence of putrefactive anaerobic spores in meat obtained from five commercial packing plants located in different parts of Iowa. In addition to studies on fresh and cured pork trimmings and pork luncheon meat, a limited investigation was made of the spore content in fresh beef. Since various curing agents are added to pork luncheon meat, the ability of these agents to inhibit growth of putrefactive anaerobes was investigated. Relationships of various anaerobes isolated from meat to known cultures of putrefactive anaerobes were studied serologically.

In the investigations on incidence of putrefactive anaerobic spores in meat, ninety per cent of fresh pork trimmings obtained from four packing plants contained less than three spores per gram. Spore counts on samples from different plants were similar. The maximum spore count found in any sample tested was 51 spores per gram. Cured pork trimmings obtained from two commercial packing plants contained less than three spores per gram in ninety per cent of the samples. The maximum spore count was 43 spores per gram. Ninety-four per cent of the samples of pork luncheon meat in six pound perishable packs contained less than two spores per gram. Commercially sterile pork luncheon meat in 12 ounce cans obtained from two plants contained in every case less than 0.18 spores per gram.

Ten samples of fresh beef obtained from one packing plant contained an average of 6.5 spores per gram.

It was necessary to evaluate the method used in determining the incidence of putrefactive anaerobic spores in meat. This

was accomplished by adding known numbers of viable spores of putrefactive anaerobe 3679 to various samples of meat and testing for recovery. Recoveries of known viable spore loads from fresh and from cured pork trimmings appeared to be complete. Recoveries of spores from pork luncheon meat were less satisfactory but acceptable in view of the low incidence of spores in this type of product. When mixed with P. A. 3679 spores, the ether soluble fraction of commercially sterile pork luncheon meat caused a significant decrease in the numbers of spores that were recovered.

Addition of sodium bicarbonate to Linden thioglycollate starch medium did not appreciably increase counts of spores from fresh pork trimmings. Preliminary enrichment of vegetative cells able to grow anaerobically after a mixing operation in a Waring blender jar failed to increase counts of putrefactive anaerobic spores found in meat.

Experimental variations obtained from repeated sampling of the same meat reflected differences in spore counts that would normally be expected using the most probable numbers technique.

The effect of curing agents on inhibition of spore growth was investigated in solid and in liquid Linden thioglycollate starch media as well as in fresh pork trimmings and in pork trimmings heated to 80°C. (176°F.) for 20 minutes in order to destroy vegetative cells. Sucrose in concentrations up to 45 per cent exhibited no inhibitory effect upon growth of putrefactive anaerobes in a liquid medium. Ten per cent sucrose added to fresh pork trimmings had no preservative effect. In general, a commercial concentration of sodium nitrate (0.125 per cent) was inadequate to prevent growth of putrefactive anaerobic spores. However, in fresh pork trimmings, nitrate exhibited a limited preservative effect similar to nitrite. The inhibitory effect in this substrate may have been due to reduction of nitrate to the more active nitrite by vegetative cells. The concentration of sodium nitrate necessary to prevent growth of pure cultures of putrefactive anaerobes in Linden thioglycollate starch medium was similar to the con-

1 a. Chairman of Committee, John C. Ayres, Associate Professor, Dept. of Bacteriology, Agricultural Experiment Station.

b. Doctoral Thesis No. 1160. Submitted April 6, 1951.

2 a. B. A., University of Minnesota, Minneapolis, Minnesota, 1939.

b. Industrial Fellow, Agricultural Experiment Station.

centration of sodium chloride necessary to inhibit growth. In commercial concentration (0.015 per cent), nitrite exhibited a definite inhibition of growth when the inoculum of putrefactive anaerobic spores was small. There was evidence that organisms gradually reproduced. This may have been due to disappearance of nitrite from the medium as has been reported by some workers or to development of tolerance for the curing agent. In the presence of large inocula of spores, nitrite in commercial concentration appeared to be ineffective.

The curing agents in combination in concentrations used commercially were able to preserve fresh pork trimmings containing 20 putrefactive anaerobic spores per gram for a minimum period of one month when incubated at 37°C. (98.6°F.). This was a severe test and indicated that the curing agents have a definite preservative action. It appears that, with the

concentrations of curing agents tested, commercial levels in combination exhibited the greatest preservative effect in fresh pork trimmings.

Of representative obligate anaerobic species isolated from meat, organism No. 17, tentatively identified biochemically as *Cl. carnis*, appeared to be identical serologically with the well-known spoilage organism P. A. 3679. Organisms No. 74 and No. 75 identified biochemically as *Cl. sporogenes* were identical serologically. Although they had some antigens in common with *Cl. sporogenes* strain Spray, they were not identical with it. Organism No. 4, biochemically similar to P. A. 3679, showed no relationship serologically to the known spoilage organism. It did have some antigens in common with organism No. 74. Cultures No. 7 and No. 73 tentatively placed in the species *Cl. tetanormorphum* showed a relationship serologically to the *Cl. sporogenes* group.

CLOUD CHAMBER MEASUREMENT OF ELECTRON PAIRS FOR DETERMINATION OF SYNCHROTRON SPECTRUM¹

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Department of Physics

The X-ray spectrum of the Iowa State College synchrotron operating at 65 Mev. has been measured. The method consisted of the observation, in a magnetic cloud chamber, of the momentum of each member of electron pairs produced in the air filling of the chamber. Using the theoretical values of cross section for pair production and the results of recent experiments, the energy spectrum of the X-ray quanta was computed. Due to the pronounced forward directional characteristic of electron pairs produced at extreme relativistic energies, discrimination of one energy region with respect to another was avoided and no solid angle corrections were necessary. The results are in agreement with the energy spectrum predicted by the Bethe-Heitler theory.

During observation of a portion of the data, the synchrotron beam intensity was monitored and related to the reading of a Victoreen thimble ionization chamber in a single ended lead cylinder one-eighth inch thick. This procedure enabled a value to be obtained for the flux of quanta and energy, related to the reading of the Victoreen chamber in r units. A quantum flux of 6.6×10^7 quanta per square cm. per r unit was obtained for the interval 10-65 Mev. For the region 0-65 Mev. a value of 2.2×10^8 Mev. per square cm. per r unit was obtained for the energy flux. These values are in agreement with the possible comparisons with independent work and will enable absolute values of the cross section for nuclear gamma reactions to be made.

The method used for measurement of the stereoscopically projected electron tracks is described in the Appendix and expressions are derived for obtaining the magnitude of the electron momentum from the measured quantities.

1 a. Chairman of Committee, L. Jackson Laslett, Associate Professor, Dept. of Physics, Institute for Atomic Research.

b. Doctoral Thesis No. 1166. Submitted June 4, 1951.

2 a. B. S., Case Institute of Technology, Cleveland, Ohio, 1942.

b. Junior Physicist, Institute for Atomic Research.

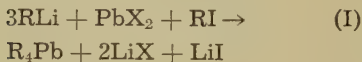
MECHANISMS OR REACTIONS INVOLVED IN THE PREPARATION OF ORGANOLEAD COMPOUNDS CONTAINING WATER-SOLUBILIZING GROUPS¹

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Department of Chemistry

Organometallic compounds of lead are well known and have been the subject of considerable investigation during the ninety-eight years since their discovery. One important problem which remains in connection with these compounds, however, is that of developing convenient and effective methods for the introduction into organolead molecules of various types of functional groups, especially of groups which will confer on the molecule the property of water solubility. The objectives of the present investigation, therefore, were (a) to study the nature and scope of certain reactions which might be useful for this purpose, and (b) to prepare by these reactions representative examples of water-soluble organolead compounds for physiological testing.

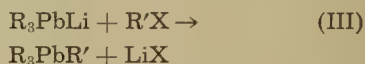
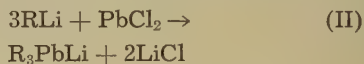
One synthesis of symmetrical organolead compounds recently reported from this Laboratory involves the reaction of a lead halide with an organolithium compound in the presence of the corresponding organic iodide. The reaction is carried out in refluxing ether.



This reaction was investigated further, in its application to aryllead compounds, and was found to be a method of choice for the preparation of tetraphenyllead. Tetra-*p*-dimethylaminophenyllead was prepared in this way in 63 per cent yield, as compared with 17 per cent by former methods.

The tetra-*p*-dimethylaminophenyllead gave a tetramethiodide, m. p. 187–189° (which is the m. p. of the original compound and therefore apparently indicates decomposition). The tetramethiodide was soluble in water to the extent of 0.5 g. per 100 ml. It was tested against mouse sarcoma at the National Institute of Health, but evaluation of the results is not yet complete.

It was found that unsymmetrical lead compounds of the type $\text{R}_3\text{PbR}'$ (where R is aryl and R' alkyl) were readily prepared by the reaction of alkyl halides with a triaryllead lithium compound. The latter intermediate was obtained by the action of the aryllithium compound on lead chloride in ether at –10°.



By such reactions the following known unsymmetrical compounds were prepared directly from lead chloride: Triphenylbenzyllead (69 per cent); triphenylethyllead (45 per cent); triphenyl-*n*-propyllead (63 per cent); and tri-*p*-tolylbenzyllead (65 per cent). New compounds prepared in this way included triphenyl- γ -diethylaminopropyllead (91 per cent, liquid); triphenyl-*p*-bromobenzyllead (67 per cent, m. p. 66–68°); 1,3-bis(triphenyllead)propane (58 per cent, m. p. 94–95°); and 1,4-bis(triphenyllead)butane (46 per cent, m. p. 134–136°). Triphenyl- γ -diethylaminopropyllead gave a methiodide, m. p. 153–155°, insoluble in water; and a methosulfate, m. p. 137–138°, which was extremely soluble in water and apparently surface-active. This latter material is at present undergoing pharmacological tests. Triphenyl- γ -diethylaminopropyllead treated with hydrogen chloride in ben-

1 a. Chairman of Committee, Henry Gilman, Professor, Dept. of Chemistry, Industrial Science Research Institute.

b. Doctoral Thesis No. 1135. Submitted December 14, 1950.

2 a. B. S., Iowa State College, Ames, Iowa, 1939.

M. S., Utah State College, Logan, Utah, 1941.

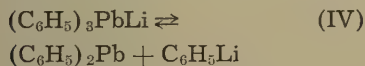
b. Graduate Assistant, Industrial Science Research Institute.

zene was cleaved completely, to give lead chloride; but with 5 per cent aqueous hydrochloric acid there resulted diphenyl- γ -diethylaminopropyllead chloride hydrochloride,



white crystals which on heating decomposed without melting.

Studies of the nature and of the mechanism of formation of the triphenyllead-lithium preparations indicated the existence of an equilibrium of the type



As expected from this formulation, it was found that carbonation, with carbon dioxide gas, of preparations made with from two to three equivalents of phenyllithium per mole of lead chloride always gave near 50 per cent yield of benzoic acid based on the amount of phenyllithium present over two equivalents, whatever that amount was. Carbonation of a preparation made using two equivalents of phenyllithium followed by one equivalent of *p*-tolyllithium gave not only *p*-toluic acid but also benzoic acid, indicating an equilibration of groups around the lead, presumably through reactions similar to IV. In agreement with this, attempts to prepare compounds of the type $\text{R}_2\text{PbR}'\text{R}''$ (R and $\text{R}' = \text{aryl}$; $\text{R}'' = \text{alkyl}$) by reactions like II and III did not give pure products. With RX compounds which would react with phenyllithium, such as *p*-nitrobenzyl chloride, reaction III did not give unsymmetrical organolead products. *m*-Bromoaniline also reacted, apparently, with the phenyllithium component of equation IV. Compounds such as 1,3-dibromopropane, 1-bromo-3-chloropropane, or 1-bromo-4-chlorobutane reacted readily with triphenyllead-lithium to give the bis-derivatives described above; but attempts to carry out reactions with these halides in such a way as to obtain, for instance, 1-bromo-3-(triphenyllead)propane gave mixtures which could not be purified, although there were indications that the desired products were present.

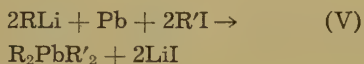
Triphenyllead-lithium was found to be essentially insoluble in ether. The prepa-

rations at the diphenyllead stage (that is, when two equivalents of phenyllithium had been added per mole of lead chloride) were bright yellow in color, and decomposed on heating to give metallic lead and hexaphenyldilead. It was therefore necessary to maintain a low temperature during addition of the phenyllithium to the lead chloride. At the triphenyllead-lithium stage the preparations consisted of a grayish-white solid in a light-yellow liquid; and after this stage had been reached the liquid was stable to heat, indicating that the equilibrium IV must be shifted far to the left as written, or perhaps that there is a favorable temperature effect on the equilibrium.

Some experiments were carried out in which germanium diiodide, GeI_2 , was treated with phenyllithium. The behavior was not the same as in the case of lead. The germanium diiodide reacted only slowly with the phenyllithium, and required several days' refluxing before it absorbed three equivalents of the RLi compound. The preparation was then orange-brown. It did not react with benzyl chloride. The benzyl chloride reaction mixture, after hydrolysis, gave a product which was mostly diphenylgermanium, although some tetraphenylgermanium was isolated.

In other studies, it was shown that *m*-bromoaniline will undergo halogen-metal interconversion with *n*-butyllithium, and from the interconversion product there was obtained *m*-aminophenyltrimethylsilane. The yield was very low because of difficulty in purification of the product. The b. p. was about $77-84^\circ/1.5$ mm. In a similar way there was obtained, also in low yield (2 per cent), *m*-aminophenyltriphenylsilane, m. p. $248-251^\circ$. Triphenylchlorosilane with α -monosodium glyceroxide yielded triphenyl- α -glyceroxysilane (18 per cent, m. p. $139-142^\circ$), which with hot ethanol gave triphenylethoxysilane. Sodium triphenylsilanolate and triphenyllead chloride gave triphenyllead triphenylsilanolate, white crystals, m. p. $123-124^\circ$, in 56 per cent yield.

Experiments were also carried out in which the possible use of metallic lead for the preparation of $\text{R}_2\text{PbR}'_2$ compounds ($\text{R} = \text{aryl}$; $\text{R}' = \text{alkyl or aryl}$) by reactions of the type



was investigated. Phenyllithium and ethyl iodide reacted readily with the lead powder to give diethyldiphenyllead in an impure state. It could not be purified readily. A little ethylbenzene was also found. The reaction of lead with phenyllithium and *p*-iodotoluene, and also with phenyllithium and methyl iodide, was investigated. The lead dissolved readily on heating in each case. The products were impure, however, due probably to displacement, coupling, and perhaps interconversion reactions. The procedure did not appear to be of probable synthetic value, since

a more clean-cut reaction is desirable for the preparation of compounds of this sort, whose sensitivity is such that any very drastic methods of purification cannot be applied.

The literature on organolead compounds for the period from 1941 to the present time was surveyed, and a complete tabulation was made of all organolead compounds which have received mention in the literature during this period. A survey was also made of the existing information regarding certain valence states of lead and of the other elements of Group IV-B.

DESTRUCTION OF MAIZE ROOTS BY *PYTHIUM GRAMINICOLA* SUBR. AND *DIABROTICA UNDECIMPUNCTATA* HOWARDI BARBER¹

THOMAS E. SUMMERS²

Department of Plant Pathology and Department of Zoology

Maize plants exposed to *Pythium graminicola* Subr., to larvae of *Diabrotica undecimpunctata howardi* Barber, and to a combination of *P. graminicola* and *D. undecimpunctata howardi* larvae were compared with check plants grown in noninfested steamed soil. The variables measured and compared were, number of brace roots developed, number of ear shoots produced, dry weight of roots, dry weight of tops, dry weight of ear shoots and total dry weight of plant.

The relative number of brace roots as compared to the number produced by check plants was 74.0 per cent for the plants exposed to *P. graminicola*; 51.3 per cent for plants exposed to *D. undecimpunctata howardi*; and 78.9 per cent for the plants exposed to a combination of *P. graminicola* and *D. undecimpunctata howardi* larvae.

Plants exposed to *P. graminicola* produced 86.1 per cent as many ear shoots

as the check plants; these shoots weighed 53.2 per cent as much as ear shoots of the check plants. Plants exposed to rootworm attack produced 44.2 per cent as many ear shoots, which weighed 40.0 per cent as much as check plants shoots. Plants exposed to both *Pythium* and rootworm larvae produced 76.0 per cent as many shoots which weighed 48.0 per cent as much as did the ear shoots of the check plants.

Relative dry root weight for plants exposed to *Pythium* was 74.9 per cent; plants exposed to rootworm larvae 59.1 per cent; and plants exposed to both *Pythium* and rootworm larvae 81.4 per cent of check plants root weight.

Total dry weight expressed as a percentage of dry weight produced by check plants was for *Pythium* exposed plants, 63.0 per cent; plants exposed to rootworm larvae 47.7 per cent; and plants exposed to *Pythium* plus rootworm, 57.0 per cent.

It is evident that both *P. graminicola* and *D. undecimpunctata howardi* larvae appreciably reduced root and top development by maize plants. Of particular interest was the degree to which ear weight was reduced on plants exposed to either or both these agents of root destruction.

The fungi isolated most frequently in August and September from secondary roots, the stele of secondary roots, root tips and tissue from the lower three inter-

- 1 a. Chairman of Committee, W. F. Buchholtz, Associate Professor, Dept. of Botany, Agricultural Experiment Station.
Oscar E. Tauber, Professor, Dept. of Zoology and Entomology, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1093. Submitted July 15, 1950.
- 2 a. E. S. A., University of Georgia, Athens, Georgia, 1941.
M. S., Iowa State College, Ames, Iowa, 1947.
- b. Associate, Agricultural Experiment Station.

nodes of corn stalks were *Pythium graminicola* and *Pythium arrhenomanes*, *Gibberella saubinetii*, *Fusarium* spp., *Pythium* spp. other than *P. graminicola* and *P. arrhenomanes* and various other fungi in lesser numbers.

There was no difference in the time at which *P. graminicola* became associated with the roots of corn plants grown in soil which had remained dry for 16 months after removal from the field and corn roots grown in soil remaining dry for the same length of time but watered daily for 15 days prior to planting with leachings from pots containing growing corn roots. *P. graminicola* did not become associated to an appreciable degree with the roots of corn seedlings until after the sixteenth day following planting.

Data collected during October, 1949, showed stalk lodging of corn to amount

to 38.6 per cent for forty-five fields located in fifteen counties of Iowa. Root lodging for the forty-five fields was 15.7 per cent. Seventy-eight per cent of the stalk-lodged plants were broken at a point of corn borer (*Pyrausta nubilalis*) damage. The per cent of broken stalks showing stalk rot but no corn borer damage was 9.9. Root lodging in fields in which corn had preceded corn averaged 30.9 per cent, in fields in which the preceding crop was oats, root lodging averaged 7.7 per cent and in fields following soybeans, root lodging averaged 4.4 per cent. There were 30.9 per cent root lodged plants in fields in which the preceding crop was corn, 7.7 per cent in fields in which oats were grown the preceding year, and 4.4 per cent in fields where corn followed soybeans.

MASS SPECTROMETRY

I. THEORY AND CONSTRUCTION OF MASS SPECTROMETERS

II. KINETICS OF REACTION OF URANIUM WITH H₂, HD and D₂¹

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Department of Chemistry

In recent years the mass spectrometric art has progressed rapidly from a laboratory specialty to the place where now many mass spectrometers are employed as tools in routine chemical analyses. Improvements have been incorporated into the design of these instruments which have greatly simplified their operation. The purpose of the present work was to construct a mass spectrometer that would operate in the range 1-75 mass units. However, because of the special problems involved in the mass spectrometric assay of the hydrogen isotopes a separate machine was built for this purpose. A second machine covers the entire range 1-75 mass units although it is not being used for hydrogen analyses.

Both mass spectrometers employed a double ion collector system. In the hydrogen machine the ion pairs H₂⁺ and HD⁺ or D₂⁺ and HD⁺ are collected simultaneously after having been bent in a 60° sector magnetic field to a radius of about 5 centimeters. The mass spectrometer of range 1-75 mass units will simultaneously collect ion currents due to the ion pairs C¹³O₂¹⁶⁺, C¹²O₂¹⁶⁺, O¹⁶O¹⁸⁺, O¹⁶O¹⁶⁺, and N¹⁴N¹⁵⁺, N¹⁴N¹⁴⁺ after they have been bent in the 60° sector magnetic field along a radius of about 15 centimeters. Determination of isotopic abundance ratios in both the hydrogen and larger machine is achieved using a null method. This method consists of applying the output potential of the amplifier used to amplify the largest ion current across a potentiometer and then using a portion of this output potential to balance out the effects of the lesser ion current being amplified by a second amplifier. Hence the abundance ratio of the isotopes being determined by the mass spectrometers may be obtained from a knowledge of the total

- 1 a. Chairman of Committee, Frederick R. Duke, Associate Professor, Dept. of Chemistry, Industrial Science Research Institute, Institute for Atomic Research.
- b. Doctoral Thesis No. 1028. Submitted March 13, 1950.
- 2 a. B. S., John Carroll University, Cleveland, Ohio, 1941.
- b. Associate Chemist and Assistant Professor, Institute for Atomic Research.

resistance of the potentiometer and the resistance of that portion from which the required balancing potential was obtained. Thus to determine the isotopic abundance ratio of the constituents in a gas sample it is only necessary to achieve a balance and then read the result directly from the position of the movable tap on the potentiometer.

For the sake of simplicity the hydrogen mass spectrometer is partly battery and partly line operated. The larger machine is completely line operated. Except for water to cool the vacuum pumps only a source of 110 volts, 60 cycle alternating current is required to operate the machine.

Performance of the hydrogen mass spectrometer indicates that the precision with which isotopic abundance ratios can be determined is ± 1 per cent. The machine is sensitive enough to determine a D/H ratio in a sample of hydrogen of one part in 40,000.

The mass spectrometer of range 1-75 mass units has been tested by assaying samples of nitrogen for their N_2^{29} content. Performance of the machine in these tests indicates that a difference of 0.25 per cent in the N_2^{28}/N_2^{28} ratio can be easily determined.

Considerable attention has been given to the reaction between finely divided uranium metal and hydrogen. Pressure-composition studies have shown that equilibrium in this reaction is obtained very slowly; in some cases as long as several days are required to obtain equilibrium. By observing the reaction during a very short reaction time (about 20 seconds) the kinetics of the forward reaction can be determined essentially exclusive of the backward reaction. In order to compare the metal- H_2 reaction with those of metal-HD and metal- D_2 , a mixture of these gases was allowed to pass at a con-

stant rate over a bed of finely divided uranium maintained at some predetermined temperature.

The gas that passed the uranium metal was analysed for its H_2 , HD and D_2 content. For every temperature at which observations were possible, the rate of reaction followed the order H_2 faster than HD faster than D_2 . Two possible explanations may be given for the observed difference in reactivities of the various hydrogen molecular species. The difference may be due to the different rates at which the gaseous molecules diffuse into the metal or it may depend entirely upon the difference in the zero-point energies of the gaseous molecules. Thus the ratios of the reaction rates for the various molecular species of hydrogen would vary inversely as the square root of their masses if diffusion is the main factor governing the rate of reaction or inversely as the square root of their reduced masses if the zero-point energy is the controlling factor. Table 1 summarizes the theoretical values of the ratios of the reaction rates for both diffusion and zero-point energy interpretations along with the observed ratios at several experimental temperatures. In the table k_1 refers to the reaction involving uranium and H_2 ; k_2 , uranium and HD; and k_3 , uranium and D_2 .

On the basis of this information alone it is impossible to state which is the better of the two alternate views. However, many workers have reported the rate of diffusion of gases into metals other than uranium to be a very slow process. Since the experiments described here were of very short duration it is probable that diffusion plays a minor role in the initial reaction rate. It is more probable that the observed differences in the rates of reactions for the hydrogen molecular species and uranium metal are concerned primarily with the differences in the zero-point energies of the gaseous molecules.

TABLE 1
RATIOS OF THE REACTION RATES OF H_2 , HD AND D_2 WITH URANIUM METAL

	Diffusion	Zero-Point Energies	Observed					
			27.5 °C	35 °C	45 °C	50 °C	60 °C	75 °C
k_1/k_2	1.23	1.15	1.25	1.15	1.13	1.11	1.14	1.14
k_1/k_3	1.42	1.41	1.03	1.83	1.71	1.58	1.60	1.58
k_2/k_3	1.16	1.22	1.06	1.60	1.44	1.42	1.40	1.30

In the observations made in these laboratories the processes are concerned mainly with the adsorption of the gaseous molecules by the metal.

Energies of activation for the processes have been determined using the Arrhenius relationship,

$$\frac{d \ln k}{dT} = -\frac{E}{RT^2}.$$

A plot of the reaction rate data for several experimental temperatures indicates

that the points follow a straight line. From the slopes of the lines the activation energies have been calculated. The activation energies are $8,200 \pm 200$ calories for the process involving H_2 molecules; $8,500 \pm 200$ calories for the process involving HD molecules and $10,200 \pm 200$ calories for that involving D_2 molecules. It is not possible to state that these are the true activation energies since these values include the heats of adsorption which are not determinable for the observed processes.

AGRICULTURAL RESOURCE PRODUCTIVITY AND ATTITUDES TOWARD THE USE OF CREDIT IN SOUTHERN IOWA¹

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An optimum allocation of agricultural resources may be defined within the framework of welfare economics. However, the utilization of the contemporary theory of welfare economics in an empirical study is limited. The difficulties encountered center in the derivation of consumer indifference surfaces. Techniques are available, however, for testing a production configuration to determine if it is consistent with a welfare optimum. Viewing welfare in the partial sense of considering only the production sector, a necessary condition for the maximization of total welfare is the equation of marginal value productivities of resources.

Data for testing the hypothesis of an optimum resource allocation may be obtained from two sources. Production functions from farm records yield estimates of the marginal productivities of rather broad classes of inputs. Federal Census data may be used to estimate average resource productivities and under special assumptions, marginal productivities.

An analysis of agricultural resource productivity among type-of-farming areas in Iowa in 1939, 1940 and 1945 indicates cer-

tain marked divergencies from the optimum production conditions. A 1939 production function study indicates that marginal returns to livestock and feed in the Southern Pasture Area were significantly higher than in other areas of Iowa.

The total values of production per worker in 1940 and 1945 as derived from the Census are presented in Table 1.

In both years the value produced per worker for all of Iowa agriculture was nearly twice as high as that of the Southern Pasture Area. Over the period 1940-1945 the value of product per worker showed a marked increase. Much of this can be explained by the price rise. The inter-area differences in worker productivity were only slightly affected, the Southern Pasture Area exhibiting a slight improvement in its relative position. Since the livestock additions in this area 1940-1945 were the smallest in the state, support is given to the estimated high marginal productivity of livestock in this area. Increases in land per worker were rather uniform throughout the state and increases in machinery and equipment are not likely to be reflected in increased value of product per worker over such a short period.

An explanation is needed for the greater rate of livestock capital expansion by farmers in stronger financial positions. The fact that marginal returns to livestock in the Southern Pasture Area are high at a more recent date is evidenced by the results of a production function. For 1949-1950 the estimated marginal returns for

1 a. Chairman of Committee, Earl O. Heady, Professor, Dept. of Economics and Sociology, Agricultural Experiment Station.

b. Doctoral Thesis No. 1146. Submitted February 5, 1951.

2 a. B. S., University of Illinois, Urbana, Illinois, 1943.
M. S., University of Minnesota, Minneapolis, Minnesota, 1948.

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TABLE 1
VALUE OF FARM PRODUCTS SOLD, TRADED OR USED BY FARM* HOUSEHOLDS, BY TYPE-OF-FARMING
AREAS: IOWA, 1940 AND 1945*

Type-of-Farming Area	1940	1945
	<i>(In dollars per worker)</i>	
Northern cash grain.....	2,065	4,838
Western meat production.....	1,798	4,679
North central cash grain.....	1,930	4,507
Eastern meat production.....	1,493	3,679
Northeast dairy.....	1,293	3,268
South central pasture.....	1,191	2,837
Southern pasture.....	827	2,085
State.....	1,537	3,809

* U. S. Census of Agriculture. 1945. Vol. I. Part 9. 1947.

a dollar invested in livestock and feed in this area is 61 cents. One tentative explanation of both the slower rate of livestock expansion and the apparent high rate of return to this form of capital is that farmers in this area do not have adequate credit facilities.

A simple criterion of adequacy in the production credit market may be established. This consists of a situation that permits a farmer to borrow if he so desires. Of the farmers interviewed in the Southern Pasture Area in 1950 only 2.8 per cent indicated they were restricted from borrowing by lending institutions. This leads to an examination of reasons for not using more borrowed funds to expand enterprises on present acreages. The reasons given by farmers in the survey were about evenly divided between (1) those who refrained from borrowing because of some limitation of one or more of the factors of production, and, (2) those who felt that the deterioration of their present equity and the consequent loss of ability to bear uncertainty would not be compensated by the expected increase in returns.

Given the objective of increasing re-

turns per worker in this area, certain implications of the reasons given should be noted. Farmers responding with answers stressing such limitational factors as age or health would probably not be able to increase their productivity even if their present enterprises were increased. Reasons that emphasized scarcity of labor seem incongruous with respect to the estimated low productivity of this resource. Apparently an improvement in the distribution of the present labor force among farms would increase the product per worker. The limitational factor of unavailable land for rent or purchase was frequently mentioned. Given the intensity of culture, an improvement in productivity in this case would involve an exodus of some workers from this area.

Construction of a policy is problematic in the case of increasing the productivity of farmers who indicated that aversion to uncertainty aggravated by borrowing was the primary cause for refusal to borrow. Very little is known concerning the reactions that would occur if farmers faced less uncertainty.

Exploratory work in the study of uncertainty consists of the establishment of

TABLE 2
A COMPARISON OF UNCERTAINTY INDEX RANKINGS FOR CERTAIN CLASSES OF LIVESTOCK
SOUTHERN IOWA, 1950

Livestock Class	Index	
	Direct Ranking	Per Cent Expansion
Feeder cattle.....	1	1
Poultry.....	2	6
Sheep (native).....	3	3
Hogs.....	4	4
Dairy cattle.....	5	5
Beef herd.....	6	2

uncertainty indices. In the special case of the farmer considering only the various alternative livestock enterprises, an ordinal index of uncertainty may be estimated. This was done by asking farmers in the sample survey to rank livestock enterprises on the basis of their "riskiness." Another index for livestock may be the per cent expansion of the different enterprises under conditions of a greatly improved capital position. It would be expected that the more uncertain enterprises would be expanded to a greater

degree. A comparison of the results of these two indices is presented in Table 2. An index ranking of one indicates that the farmers, on the average, considered this enterprise to be the most uncertain as defined above. The rank correlation coefficient between these two indices is not statistically significant at the 5 per cent level of probability. This aspect of the investigation should be considered as preliminary to more complete analysis that will perhaps yield results of greater value in the formulation of social policy.

A PORTABLE FOUR-ELECTRODE PROBE FOR MEASURING SOIL MOISTURE¹

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There is an urgent need in soil-physics research for more accurate information on soil moisture. This applies to the absolute amount of moisture both in soil and in water movement. Other phases of soils research require a knowledge of soil-moisture conditions. For example, soil reaction, the availability of certain mineral elements to plants, and the growth of various soil micro-organisms are all affected by the amount of soil moisture.

A review of the literature showed many limitations in the present methods of measuring soil moisture. Considerable work has been done with the use of electrodes buried in the soil. The resistance between two electrodes buried in the soil might well be related to moisture content if the electrodes kept perfect contact with the soil. The contact between the electrodes and the soil is neither perfect nor is it constant even for a short period of 3 to 8 days. For this reason, the resistance between two electrodes buried in the soil cannot be experimentally related to moisture content. The use of four, instead of two, electrodes in the soil offers a means of eliminating the varying contact re-

sistance between the electrode and the soil. The arrangement of the four electrodes constitutes a four-terminal conductor. This conductor is one provided with two terminals to which current leads may be connected and two terminals to which potential leads may be connected. The resistance of such a conductor is the difference in potential between the potential terminals divided by the current entering and leaving through the current terminals. The contact resistance between the current terminals and the soil only affects the current flowing between them. Since the current is measured, the effect of the contact resistance is known. Further, by using a vacuum-tube voltmeter to read potential differences across the potential terminals, contact resistances between these terminals and the soil do not enter into the measurements. The conductivity of a homogeneous medium can be determined by measuring the resistance of the conductor and knowing the geometric arrangement of the electrodes with reference to each other and to the boundaries of the medium. The type of contact made between the soil and the electrodes is not important. The only restriction in using this type conductor is that the terminals must be small compared to the distances separating them.

In the present study an electrical conductivity method using four electrodes in the soil has been developed for the measurement of soil moisture *in situ*. The method is unique in two ways: one is

- 1 a. Chairman of Committee, Willard Gardner, Professor, Depts. of Agronomy and Physics. F. F. Riecken, Professor, Dept. of Agronomy, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1123. Submitted December 7, 1950.
- 2 a. B. S., North Carolina State College, Raleigh, N. Carolina, 1943.
- b. M. S., *ibid.*, 1949.
- b. Graduate Assistant, Agricultural Experiment Station.

that the soil serves directly as the conducting medium and the other is that no time delay is required for the soil unit to reach equilibrium with the soil.

The method does not measure soil moisture directly but rather the electrical conductivity of the soil. The relationship between moisture and electrical conductivity must be determined experimentally.

The apparatus consists of a portable four-electrode probe which acts as the soil unit and an accompanying meter. The probe and the electrical equipment in the meter are shown schematically in Figure 1. The probe consists of four steel rods which are insulated except at the ends. The ends are pointed and serve as the electrodes. The steel rods, rigidly built into one unit, are equally spaced with the pointed ends in a line. The insulation on the rods is Tygon, an insulating paint, which when dry is highly resistant to abrasive action. The purpose of the meter is to supply alternating current at a frequency of 400 cycles and to measure potential differences.

In using this method, the procedure is to push the probe into the soil at a depth determined by an adjustable stop. With the probe in the soil, electric current I is applied to the outer electrodes and the resultant potential drop V_i developed across the inner electrodes measured. The current I is not measured directly but is calculated from the potential difference V_0 measured across a known resistance R_a in series with the two outer electrodes. The specific conductivity of the soil is then determined from the formula

$$\sigma = \frac{n}{4\pi a} \left(\frac{I}{V} \right) = \frac{n}{4\pi a} \frac{V_0}{R_a V_i} \quad (1)$$

where

$$n = 1 + 2 \left[\left(1 + \frac{4b^2}{a^2} \right)^{-1/2} - \left(4 + \frac{4b^2}{a^2} \right)^{-1/2} \right] \quad (2)$$

Conductivity versus moisture content and conductivity versus temperature curves were obtained for several Iowa soils using the four-electrode method. All of the conductivity-moisture content curves showed characteristic flex points. The conductivity-temperature curves were approximately linear for the range of tem-

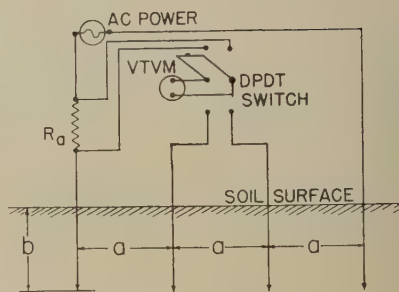


FIG. 1.—Schematic diagram of the portable four-electrode probe and accompanying meter for measuring soil moisture.

peratures studied. These curves showed that the effect of temperature on conductivity was nearly independent of moisture content.

Field measurements using the portable four-electrode probe were obtained during two summers. These data showed that the accuracy of measuring soil moisture with the four-electrode method was less than the accuracy of the weighing method. To give the same degree of accuracy, approximately three times as many measurements of conductivity must be obtained as the number of soil samples for oven-drying. Coefficients of variation for determining soil moisture by the portable four-electrode probe ranged between 13 and 35 per cent, depending on the moisture content and the compaction of the soil. It was shown that bending of the electrodes from their theoretical positions

would introduce large errors in the conductivity measurements.

Since there is no waiting time for the electrodes to reach equilibrium with the soil, a large number of conductivity measurements can be obtained in a short time. One hundred measurements of soil

conductivity were obtained in one hour by a person using the portable probe and the accompanying meter. Further, there are not any underground parts which must be replaced from year to year.

The laboratory calibration of electrical conductivity versus soil moisture content showed that soil moisture could be studied over the range from the wilting percentage to saturation. The greatest accuracy in

measuring soil moisture over this range is obtained near the moisture equivalent, and the least accuracy is obtained at the ends of the moisture range.

The portable four-electrode probe is not recommended for general field use until further improvements can be made in the construction of the probe, especially in regard to eliminating the bending of the electrodes.

EFFECTS OF NATURAL SELECTION IN SEGREGATING GENERATIONS UPON BULK POPULATIONS OF BARLEY¹

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Department of Agronomy

Bulk populations of 20 barley crosses were grown for one, two, or three generations at four locations—near Shenandoah, Ames, Marcus, and Cresco, Iowa. Investigations were then conducted to determine to what extent natural selection at these locations had brought about changes in these populations. Bulk populations from seed of the several generations produced at the four locations were grown at Ames and Cresco in 1950 and evaluated for yield, plant height, and date of maturity. The same crosses also were grown in a spaced-plant test at Ames and evaluated for stand, date of heading, degree of infection by certain diseases, and segregation for certain morphological characters. Yield tests of selections made from the 20 crosses also were grown at Ames and Cresco in 1950 to measure the relationship between yields of bulk populations and yields of selections made from them.

The location at which the segregating generations had been grown had a highly significant effect upon the yield of bulk populations. Yield differences were very similar in tests at Ames and Cresco in 1950. Ames grown seed gave the highest yield, followed by seed from Marcus, Cresco, and Shenandoah. Plant height was not greatly influenced by the location at

which the seed was grown in the early segregating generations.

Date of maturity and average heading date of the bulk populations were influenced by the location at which the segregating generations were grown. Natural selection shifted the populations toward earlier maturity and heading at Ames and Shenandoah in Central and Southern Iowa and later types of Cresco and Marcus in Northeastern and Northwestern Iowa.

Seed weight also was affected by the location in which the bulk populations had been grown. Seed weight was found to be closely related to the ability of the seed to establish a stand in the spaced-plant test. Both seed weight and stand were significantly associated with yields in the bulk population tests.

Crosses that were high yielding in the bulk hybrid tests tended to produce the greatest proportions of high yielding types in the selection tests. It would have been possible to discard entire crosses on the basis of bulk yields without much loss of desirable germ plasm for yield.

Loose smut tended to build up more rapidly in the barley populations grown in northern Iowa. These results indicate that in breeding for smut resistance in barley it might be advantageous to grow bulk populations in that area. Resistance to leaf rust, stem rust, and bacterial blight apparently had not been selected for at any of the locations, probably because these diseases were not serious during the years when the segregating generations were grown.

In the spaced-plant test, segregating populations were classified for hooded

1 a. Chairman of Committee, I. J. Johnson, Professor, Dept. of Agronomy, Agricultural Experiment Station.

b. Doctoral Thesis, No. 1147. Submitted February 22, 1951.

2 a. B. S., South Dakota State College, Brookings, S. Dakota, 1942.
M. S., Iowa State College, Ames, Iowa, 1949.

b. Associate, Agricultural Experiment Station.

versus awned, six-rowed versus two-rowed, and rough-awned versus smooth-awned types. Awned types were favored over hooded and six-rowed over two-rowed for survival in the bulk populations. Neither rough-awned nor smooth-awned types showed a differential trend for survival. Differences were present among crosses and among locations for the degree of selection for each morphological character investigated.

From these investigations it was concluded that natural selection differed with location and was effective in changing

bulk populations for average heading date, maturity, and yield. No differential selection was found for plant height or disease resistance. Shifts in plant numbers for the morphological characters observed were greater than expected by chance and suggest that natural selection may rapidly change the composition of a bulk population of small grain. It was concluded that the effectiveness of the bulk method of breeding is dependent in part upon the location where the bulk populations are grown.

THE DETERMINATION OF OVERLAPPING DISSOCIATION CONSTANTS FOR DIBASIC ACIDS AND ZIRCONIUM CHLORANILATE COMPLEXES¹

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Part One: The Determination of Overlapping Dissociation Constants for Dibasic Acids

In the past the spectrophotometric determination of overlapping dissociation constants for a dibasic acid has involved approximations which limited the accuracy of the determination or required an ex-

where (a) represents the hydrogen ion concentration and $[H_2A]$, $[HA]$ and $[A]$ are the concentrations of the undissociated, singly- and doubly-dissociated forms of the acid. If the total formality (c) of the acid, the ionic strength, the length (L) of the absorption cell and the wavelength are kept constant, the optical density D is

$$(1) \quad D = \frac{Lc \left(e_1 + \frac{k_1}{a} e_2 + \frac{k_1 k_2}{a^2} e_3 \right)}{1 + \frac{k_1}{a} + \frac{k_1 k_2}{a^2}}$$

cessive amount of calculating. The present spectrophotometric method eliminates the approximations inherent in previous methods and gives the final results with relatively little numerical calculation. If the dibasic acid is represented by H_2A , its "acidity constants" are

where e_1 , e_2 and e_3 are the molar extinction coefficients of H_2A , HA and A , respectively.

The present method is applicable if the plot of D versus pH shows a maximum or minimum corresponding to the species

$$k_1 = \frac{a \cdot [HA]}{[H_2A]} \text{ and } k_2 = \frac{a \cdot [A]}{[HA]}$$

1 a. Chairman of Committee, Adolf F. Voigt, Associate Professor, Dept. of Chemistry, Institute for Atomic Research.
b. Doctoral Thesis No. 1125. Submitted December 7, 1950.

2 a. B. S., University of California, Berkeley, California, 1943.
b. Junior Chemist, Institute for Atomic Research.

HA. Putting $(dD/dpH) = 0$ from (1) gives

$$(2) \quad \frac{e_1}{e^2} - 1 + \frac{k_1 k_2}{a_0^2} \left(1 - \frac{e_3}{e_2} \right) + 2 \frac{k_2}{a_0} \left(\frac{e_1}{e_2} - \frac{e_3}{e_2} \right) = 0$$

where a_0 is the hydrogen ion concentration at the maximum (or minimum) of the curve. The optical densities for pure H_2A and pure A are $D_1 = Lce_1$ and $D_3 = Lce_3$, respectively. The maximum (or minimum) optical density D_m is from (1)

$$D_m = \frac{Lc \left[e_1 + \frac{k_1}{a_0} e_2 + \frac{k_1 k_2}{a_0^2} e_3 \right]}{1 + \frac{k_1}{a_0} + \frac{k_1 k_2}{a_0^2}}$$

Combining the expressions for D_1 , D_3 and D_m with (2), there is obtained

$$(3) \quad (k_1 k_2)^2 + a_0 [k_1 + a_0 (1 - \Theta)] (k_1 k_2) - a_0^3 \Theta [k_1 + a_0] = 0$$

$$\text{where } \Theta = \frac{D_m - D_1}{D_m - D_3}.$$

Defining $\Delta = pH - pH_0$ where $pH = -\log a_0$ there is obtained $a = a_0 10^{-\Delta}$ which when substituted in (1) gives

$$(4) \quad D = \frac{Lc \left[e_1 + \frac{k_1}{a_0} 10^{+\Delta} e_2 + \frac{k_1 k_2}{a_0^2} 10^{+2\Delta} e_3 \right]}{1 + \frac{k_1}{a_0} 10^{+\Delta} + \frac{k_1 k_2}{a_0^2} 10^{+2\Delta}}$$

Equation (4) and the expressions for D_1 , D_3 and D_m give

$$(5) \quad k_1 = a_0 \left[q_1 - 1 + (q_3 - 1) \frac{k_1 k_2}{a_0^2} \right]$$

where $(D_m - D) q_1 = (D - D_1) (10^{-\Delta} - 1)$
and $(D_m - D) q_3 = (D - D_3) (10^{+\Delta} - 1)$

Substituting (5) in (3) the two roots obtained for $(k_1 k_2)$ are

$$(6) \quad k_1 k_2 = a_0^2 \ominus = a_0^2 \left(\frac{D_m - D_1}{D_m - D_3} \right)$$

and

$$(7) \quad k_1 k_2 = \frac{Q_1}{Q_3} - a_0^2 = a_0^2 \left(\frac{D - D_1}{D - D_3} \right) 10^{-\Delta}$$

of which (7) must be discarded because it gives negative values for $(k_1 k_2)$ for values of D between D_1 and D_3 . Substitution of (6) in (5) gives

$$(8) \quad \frac{k_1}{= a_0 [(D_m - D_3) (D - D_1) 10^{-\Delta} + (D_m - D_1) (D - D_3) 10^{+\Delta} - 2 (D_m - D_1) (D_m - D_3)]} \\ (D_m - D) (D_m - D_3)$$

Since the right-hand sides of (6) and (8) contain only measurable quantities,

k_1 and $k_2 = \frac{(k_1 k_2)}{k_1}$ can be calculated

from them.

Values of k_1 and k_2 obtained for isophthalic and terephthalic acids from studies of buffered aqueous solutions in the ultra-violet are shown in Table 1. Also included are

$$k_1^* = \frac{[H^+][HCh^-]}{[H_2Ch]} \text{ and } k_2^* = \frac{[H^+][Ch^{-2}]}{[HCh^-]}$$

obtained for chloranilic acid from studies in the visible. The temperatures of spectrophotometric and pH measurement were $25 \pm 1^\circ\text{C}$. The indicated errors are probable errors. The Hückel equation was used in estimating the thermodynamic dissociation constants K_1 and K_2 .³

3 S. Glasstone, *Introduction to Electrochemistry* (1st ed.; New York D. Van Nostrand Co., Inc., 1942), Chap. 5.

Part Two: Zirconium Chloranilate Complexes

In 2M HClO_4 , chloranilic acid gives a bright magenta color with zirconium which was found to be due to two different complexes. These complexes were investigated spectrophotometrically in 2M perchlorate solutions that were 1-2M in HClO_4 and 0-1M in LiClO_4 . At the concen-

trations employed the uncomplexed zirconium could be taken to be Zr^{+4} .⁴

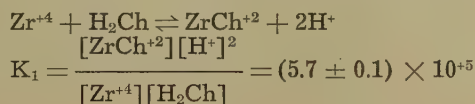
The use of Job's method of continuous variations, at concentrations of 10^{-4}M indicated the presence of a 1:1 complex. Studies of this complex at chloranilic acid formalities of 10^{-5}M were made in the presence of excess zirconium at hydrogen ion concentrations of 2.00, 1.50 and 1.00. Two hydrogen ions were liberated per

TABLE 1
ISOPHTHALIC, TEREPHTHALIC AND CHLORANILIC ACIDS

Acid	Ionic Strength	k_1 or k_1^*	k_2 or k_2^*	K_1	K_2
Isophthalic...	0.0302	$(2.8 \pm .4) \times 10^{-4}$	$(4.0 \pm .6) \times 10^{-5}$	$(2.4 \pm .3) \times 10^{-4}$	$(2.5 \pm 0.4) \times 10^{-5}$
Terephthalic.	0.0300	$(3.4 \pm 1.0) \times 10^{-4}$	$(5.5 \pm 1.6) \times 10^{-5}$	$(2.9 \pm .9) \times 10^{-4}$	$(3.5 \pm 1.0) \times 10^{-5}$
Chloranilic...	2.002	$(8.2 \pm .4) \times 10^{-2}$	$(3.8 \pm .2) \times 10^{-3}$	.....	.....

molecule of complex formed. The equilibrium was:

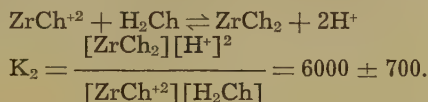
zirconium and chloranilic acid, a blue-grey precipitate formed which had a zir-



The second complex contained relatively more chloranilate but was too unstable to be identified by the usual methods. It was studied with zirconium formalities of roughly 10^{-4}M in the presence of excess chloranilic acid and at hydrogen ion concentrations of 2.00, 1.40 and 1.00. The data was best interpreted in terms of the following equilibrium:

At concentrations of roughly $5 \times 10^{-4}\text{M}$

conium-to-chloranilate ratio of 1 to (1.24 ± 0.09) . In the course of analyzing the precipitate a spectrophotometric method was developed to determine zirconium. It involved the determination of 5×10^{-6} to $5 \times 10^{-5}\text{M}$ zirconium by the use of 10^{-4}M chloranilic acid in 2M HClO_4 . Measurement in 1 cm. absorption cells at 3,400 Å gave optical densities of 0.13 to 0.80 in this concentration range.



4 R. E. Connick and W. H. Reas, *The Hydrolytic Behavior of Zirconium in Perchloric Acid Solutions*. Declassified Document

2491, United States Atomic Energy Commission, Technical Information Branch (Oak Ridge, Tennessee, 1949).

5 P. Job, *Ann. Chim.*, 10 9, 113 (1928).

EVALUATION OF THE PRODUCTION AND SUBSISTENCE LOAN PROGRAM IN IOWA¹

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Department of Economics and Sociology

A 1 per cent sample was selected from the paid-up FHA Operating Loan borrowers in Iowa. The state was divided into fourteen strata of approximately equal numbers of paid-up loans. Two counties were randomly selected, with replacement, from each stratum and ten paid-up borrowers were chosen at random from each county. To provide for refusals, incomplete records, non-standard loans, and borrowers who could not be contacted, a total of 280 farms were included in the sample. Each operator in the sample who could be located was interviewed.

All values used in the study were adjusted to a 1940 base. This was done by using the Iowa indexes of prices paid by farmers, prices received by farmers, and the Bureau of Labor Statistics Cost of Living index. This method was employed to eliminate the effects of fluctuations in the general price level.

The survey disclosed 110 clients still farming in 1949, seventy-two clients who had ceased farming, and seventeen who were deceased. The balance of the sample either refused to cooperate, could not give sufficient information to be included in the analysis, or could not be located by the interviewer.

Indexes of twenty-two farm and home conveniences indicated the FHA families had enjoyed a 141.8 per cent increase in conveniences between the time of the loan and 1949.

The wives of FHA families appeared to be better educated than their husbands. In 1949 the children were receiving substantially more high school training than either parent had.

Nearly 43 per cent of the sample operators belonged to farm organizations and 31 per cent were members of cooperatives, in 1949. At the time they received the loan the percentages were 7.3 and 6.4 respectively. Slightly less than 42 per cent reported contact with the County Extension Director in 1949.

The mean amount loaned those who have continued farming was \$896, and the amount to those who quit farming averaged \$761. Supplemental loans after the first crop year averaged \$306 for the first group and \$248 for the second group.

Those clients farming the year before receiving the loan combined average resources of 133 acres of land, of which ninety-eight acres were tillable, with 17.5 man-months of labor and \$1,047 of capital, including household goods, to earn a gross income of \$968.

The year following the loan, as reported by those clients still farming in 1949, 136.4 acres, with 101 tillable acres, were used with 16.1 man-months of labor and \$1,103 of capital, not including the loan, to earn a gross income of \$1,259.

During 1949 the paid-up borrowers used 182.7 acres on the average, of which 140 acres were tillable, with 17.7 man-months of labor and \$4,009 capital to produce \$2,309 gross income per farm.

A recapitulation showed that the resources needed to produce \$1,000 gross income before the loan were \$8,040 of land, 18.1 man-months of labor and \$1,082 of capital. The year following the loan it required \$6,595 of land, 12.8 man-months of labor and \$1,353 of capital to earn \$1,000 gross income. In 1949 the same gross income was obtained with \$5,125 worth of land, 7.7 man-months of labor and \$1,736 of capital. Diminishing returns had set in, but addition of even more capital appeared to be profitable.

The group of clients who subsequently left the farm received, on the average, smaller loans, less supplemental aid, and had smaller farms of poorer quality than those operators who were still farming in 1949.

Nearly half the funds received were

- 1 a. Chairman of Committee, William G. Murray, Professor and Head, Dept. of Economics and Sociology, Agricultural Experiment Station, Agricultural and Home Economics Extension Service, Industrial Science Research Institute.
Earl O. Heady, Professor, Dept. of Economics and Sociology, Agricultural Experiment Station.
- b. Doctoral Thesis No. 1131. Submitted December 12, 1950.
- 2 a. B.S., Iowa State College, Ames, Iowa, 1943. M.S., University of Illinois, Urbana, Illinois, 1947.
- b. Instructor, Dept. of Economics and Sociology.

spent for livestock. The group which continued farming spent a substantially larger share of the loan for power and less for refinancing than did the other group.

At the time they received the loan only 13.9 per cent of the borrowers owned their farms. When interviewed in the fall of 1949, 35.2 per cent reported ownership.

The operators still on the farm in 1949 needed an average of 4.55 years to repay their FHA indebtedness. The group that discontinued farming required 5.13 years to pay up in full. The repayment history indicated that it became more difficult for the latter group to repay after moving to town than for the operators who remained in agriculture.

The clients who left the farm were employed in a wide variety of occupations when interviewed in 1949. Their average annual income, in terms of 1940, was \$1,640, and their net worth was reported as \$2,230. Nearly 40 per cent of this group gave slow financial progress as the reason for leaving the farm. The financial progress of this group has been definitely slower than that made by the borrowers who remained on the farm.

Regression analyses were run with labor, land, capital, and management as the independent variables, and gross income as the dependent variable. Land, capital, and income were measured in terms of dollars, labor in terms of man-months and management in rating units as a per cent of 100. This rating was both objective and subjective in nature, and was applied to the operator by the writer.

In the year before the loan and in the year after the loan, the regression coefficients for land tested significant at the 5 per cent level, capital was significant at the 1 per cent level, and labor and management were non-significant. In 1949 land, capital, and management showed highly significant (1 per cent level) and

labor tested significant (5 per cent level). These regression coefficients show percentage changes in gross income for each 1 per cent factor change.

The marginal productivities of the factors, showing the absolute return in dollars of gross income for each unit change in the factor, indicate greater returns for the last unit of labor and management in 1949 than in the year immediately before or after the loan. Land and capital productivities raised the year following the loan and dipped downward again in 1949.

Examination of the regression coefficients, as measures of elasticity of the factors, revealed that the sum of the individual elasticities during each of the three periods studied indicated decreasing returns to scale for the group during the year before the loan, nearly constant returns in the year after the loan, and slightly increasing returns in 1949.

To find out whether or not any real change had taken place between the first year after the loan and 1949, a regression analysis was run using the differences in the factors as they existed in the two time periods. This regression included seventy-eight paired cases. The difference in capital tested significant at the 1 per cent level and land at about the 20 per cent level. Labor showed non-significant. Management was not tested. Thus, it was concluded that a real difference existed between 1949 and the year after the loan with respect to absolute capital accumulation and in the relative position of capital with respect to the other resources.

The study revealed that the smaller, poorer quality farms, and the excess of available labor which characterized the client families at the time of the loan, did not provide as economic a unit nor as good a resource combination as existed in 1949 after the families had enlarged their land resources.

STUDIES WITH HETEROCYCLIC COMPOUNDS CONTAINING THE AZOMETHINE GROUPING¹

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Department of Chemistry

The first part of the thesis is concerned with the reducing action of thiols on organic compounds. A review of the literature pertaining to this subject has been made. Of particular interest was the work of Gilman and Dickey,³ who found that *p*-thiocresol reduced benzalaniline, benzophenone-anil and azobenzene to benzylaniline, benzohydrilaniline and hydrazobenzene, respectively.

It was considered of interest to determine whether thiols could be used to preferentially reduce the azomethine linkage in heterocycles to their dihydro derivatives, which, except for a few compounds, have been unattainable. The simple systems like pyridine, quinoline and derivatives, isoquinoline and benzothiazole were not acted upon by *p*-thiocresol. Acridine was reduced to acridan and biacridan. The identification of biacridan was accomplished by a mixed melting point determination of the dibenzoyl derivative with a sample of 9,9'-dibenzoylbicridan which Schlenk and Bergmann⁴ prepared by the benzylation of the sodium-adduct of acridine, 9,9'-disodiobiacridan. X-ray powder diagrams of the thiol-produced biacridan and a sample of biacridan prepared by Schlenk and Bergmann⁴ were identical. Biacridan does not melt, but has a decomposition temperature which varies greatly with the method of its determination and the purity of the sample. For this reason the method of mixed melting points could not be used to identify the parent compound.

Quinoxaline was reduced to a high molecular weight compound, the structure of which is undetermined.

A novel reaction was discovered when 2-styrylquinoline was reduced to 2-(β -

phenylethyl)-quinoline. The reaction appears to be quantitative and requires two moles of thiol for each mole of olefinic compound. Similarly, 4-styrylquinoline was reduced to 4-(β -phenylethyl)-quinoline. The picrate of 4-(β -phenylethyl)-quinoline melts at 188°. There are indications that the hydrogenation of 2-styrylquinoline proceeds through the formation of an unstable intermediate, possibly of a bimolecular structure.

In each of these reactions *p*-thiocresol was oxidized to di-*p*-tolyldisulfide.

The importance of the azomethine linkage was demonstrated by the failure to obtain reduction, under forced conditions, with anthracene, styrene and stilbene. *p*-Thiocresol added to styrene to form a sulfide which was characterized by oxidizing it with hydrogen peroxide to *p*-tolyl β -phenylethyl sulfone, m.p. 72-73°.

In the second part of the thesis the synthesis of a series of hydroxystyryl derivatives of heterocycles, as potential antiseptics, is described. In addition, the preparation of certain 2-(*o*-hydroxyphenyl)-quinolines and their possible application as both antiseptics and analytical reagents is discussed.

The hydroxystyryl compounds were obtained by condensing the appropriate mono- or di-methoxybenzaldehyde with a heterocycle containing an active methyl group, in the presence of acetic anhydride. The methoxy groups were subsequently cleaved with hydriodic acid in glacial acetic acid to give the following products: 2-(*p*-hydroxystyryl)-benzothiazole, m.p. 212-213°; 2-(2,3'-dihydroxystyryl)-benzothiazole, m.p. 185-190° (dec.); 2-(3,4'-dihydroxystyryl)-benzothiazole, m.p. 220-230° (dec.); 2,6-di-(*p*-hydroxystyryl)-pyridine, m.p. 235-240° (dec.); 2,6-di-(3'-methoxy-4'-hydroxystyryl)-pyridine, m.p. 173-175° (dec.); 2,3-di-(*p*-hydroxystyryl)-quinoxaline, m.p. 220-225° (dec.); 2-(*p*-hydroxystyryl)-6-hydroxyquinoline, m.p. 270-275° (dec.).

The new methoxystyryl intermediates prepared were: 2-(*p*-methoxystyryl)-benzothiazole, m.p. 142-144°; 2-(2', 3'-dimethoxystyryl)-benzothiazole, m.p. 90-

1 a. Chairman of Committee, Henry Gilman, Professor, Dept. of Chemistry, Industrial Science Research Institute.

b. Doctoral Thesis No. 1115. Submitted October 30, 1950.

2 a. B.S., University of Vermont, Burlington, Vermont, 1939.

M.S., *ibid.*, 1941.

b. Graduate Assistant, Industrial Science Research Institute.

3 Gilman and Dickey, *J. Amer. Chem. Soc.*, 52, 4573 (1930).

4 Schlenk and Bergmann, *Ann.*, 463, 300 (1928).

91°; 2-(3',4'-dimethoxystyryl)-benzothiazole, m.p. 150-151°; 2,6-di-(2',3'-dimethoxystyryl)-pyridine, m.p. 140-141°; 2-(p-methoxystyryl)-6-methoxyquinoline, m.p. 162-163°; 2-(3',4'-dimethoxystyryl)-6-methoxyquinoline, m.p. 137-138°; 2-(2',3'-dimethoxystyryl)-4-hydroxy-6-methoxyquinoline, m.p. 278-280°.

2-(o-Hydroxyphenyl)-6-methoxyquinoline, m.p. 159-160°, was prepared by adding O-lithio-o-hydroxyphenyllithium to 6-methoxyquinoline and hydrolyzing the adduct. 2-(o-Hydroxyphenyl)-8-methoxyquinoline, m.p. 162-164°, was obtained from 8-methoxyquinoline by the same method. Hydrolysis of these compounds, by refluxing in a mixture of hydriodic acid and glacial acetic acid for twenty-four hours or more, led to 2-(o-hydroxyphenyl)-6-hydroxyquinoline, m.p. 205-207°, and 2-(o-hydroxyphenyl)-8-hydroxyquinoline, m.p. 219-221°, respectively. The latter compound was obtained also by the more direct method of adding two moles of O-lithio-o-hydroxyphenyllithium to one mole of 8-hydroxyquinoline, followed by hydrolysis. By employing the same technique, 8-hydroxyquinaldine,

which has been found to be a more selective analytical reagent than 8-hydroxyquinoline,⁵ was prepared in a 37.6 per cent yield. This synthesis has several advantages over the older ring-closure method.⁶

Unsuccessful attempts were made to add 8-hydroxy quinoline to dihydropyran for the purpose of blocking off the hydroxyl group to prevent its interference in subsequent anil-addition reactions.

Several attempts were made to add organolithium compounds to 6-methoxy-8-aminoquinoline, but each time the starting material was recovered. It appears that the N,N-dilithio compound, that is formed at first, is too insoluble in ether to undergo further reaction.

A brief survey of the antiseptic properties of phenolic compounds and the mode of action of the various types of antiseptics is given. A rather thorough review is made of the aldol and Claisen reactions of heterocycles containing active methyl groups.

5 Phillips, Elbinger and Merritt, *J. Amer. Chem. Soc.*, **71**, 3896 (1949).

6 Merritt and Walker, *Ind. Eng. Chem., Anal. Ed.*, **16**, 387 (1944).

INFLUENCE OF INBREEDING UPON MORTALITY AMONG INBRED LINES OF SWINE¹

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The effects of inbreeding on mortality in swine were studied in 174 sire groups consisting of 1,349 litters and 9,456 pigs. Each group was made up of five or more litters sired by one boar in a single season. Litters varied in size from 1 to 15 pigs. Pigs born dead were included in these counts.

The specific objectives of the study were to determine whether either inbreeding of the dam or inbreeding of the litter affected mortality at birth, mortality between birth and the 21st day, mortality between the 21st day and the 56th day, and mortality between the 56th day and the 154th day, as well as total mortality.

The data used came from records of the

12 inbred lines of Poland China swine developed and maintained at the Iowa Agricultural Experiment Station. This inbreeding experiment was initiated in 1930. It was much enlarged in 1937 to become part of the work of the Regional Laboratory for the Improvement of Swine by Breeding, organized at that time by the United States Department of Agriculture and the state agricultural experiment stations of the Corn Belt. The data included in the present study were from the years 1938 to 1949 inclusive.

Multiple regression methods were used. Since all the variances and covariances were computed within sire groups, differences between group means did not influence correlations or regressions. Sire, season and line effects were eliminated.

The dependent variables were mortality at birth, 21 days, 56 days and 154 days, and total mortality. Mortality at birth was the percentage of stillbirths. Mortality

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b. Doctoral Thesis No. 1103. Submitted August 18, 1950.

2 a. B.S., Iowa State College, Ames, Iowa, 1923. M.S., *ibid.*, 1948.

at 21 days was the percentage of additional deaths occurring before 21 days. Mortality at 56 days was the percentage of additional deaths which took place between 21 and 56 days. Mortality at 154 days was the percentage of additional deaths between 56 and 154 days. Total mortality was the percentage of all known deaths including stillbirths.

The independent variables were inbreeding of dam, inbreeding of litter, number of pigs in the litter, and age of dam. Litter size and age of dam were included in order to obtain more precise measures of the effects of inbreeding on mortality.

Increased inbreeding of the dam increased the percentage of pigs born dead, but had no significant effects at later ages. The percentage of stillborn pigs increased 1.6 per cent for each increase of 10 per cent in inbreeding of dam.

Greater mortality accompanied increased inbreeding of the litter at all ages, but the effects were significant for 154 days and for total mortality only. Total mortality increased 4.2 per cent with each increase of 10 per cent in inbreeding of the litter. Apparently increased inbreeding of the litter lowered vitality at all ages, but the effects were small until after the pigs were weaned.

The percentage of stillborn pigs decreased as litter size increased. This was not expected and is difficult to explain. Perhaps the extra vigor which contributes to increased litter size also contributes to a greater vitality at birth sufficient to more than compensate for the harmful effects of increased competition among pigs in the larger litters, before birth only. Or it may be that the smaller size of the pigs in the larger litters permits parturition to be speeded up sufficiently to lessen mortality during parturition. Then after parturition, it may be that the increase in competition among litter mates and the lessened vitality of the smaller pigs which compose the larger litters causes increased mortality. Whatever the explanation may be, mortality at 21 days increased significantly with increased litter size. After 21 days, effects were still positive but not significant.

Increased age of dam caused significantly greater mortality at birth, but the effect was not significant at 21 days. Mortality at 56 and 154 days, however, decreased significantly with increased age of dam.

Apparently, a comparatively small amount of the decrease in litter size which accompanies inbreeding in swine is due to increased mortality at birth and thereafter.

INNER-COMPLEX COMPOUNDS OF ALICYCLIC VIC-DIOXIMES¹

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Department of Chemistry

The need for a water-soluble *vic*-dioxime as an analytical reagent for nickel(II) and palladium(II) ions has long been evident. Thus, a preparation and investigation of some alicyclic *vic*-dioximes as possible water-soluble reagents was undertaken. Secondly, in order to obtain a better understanding of the structure of the inner-complex compounds that the *vic*-dioximes form with certain ions, an infrared spectroscopic study of the nature of the hydrogen bonds in these inner-complex compounds was made.

The preparation of 1,2-cyclopentanedione by the method of Riley, Morley and Friend and by a method adapted from that for the preparation of 1,2-cyclohexanedione has been studied and found to yield only small quantities of product. It is thought that the low yields result from the instability of the intermediate organo-selenium compound undoubtedly involved in the selenium dioxide oxidation of cyclopentanone. A satisfactory method for the oximation of this dione to 1,2-cyclopentanedionedioxime with hydroxylammonium chloride has been devised. This water-soluble *vic*-dioxime showed little or no promise as an analytical reagent because of the very narrow pH range over which the nickel compound is insoluble.

The use of 1,2-cyclohexanedionedioxime as a gravimetric and qualitative analytical

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reagent for nickel(II) and palladium(II) ions has been studied and reported. Its general gravimetric use is more suited to the gravimetric determination of palladium, as no satisfactory method could be devised for the determination of nickel in the presence of appreciable amounts of iron. This 6 carbon *vic*-dioxime apparently forms a very stable complex with iron(II) and slowly reduces iron(III) to iron(II) in spite of the presence of strong complexing agents for the iron(III) ion. As a qualitative reagent for nickel, 1,2-cyclohexanedionedioxime apparently has no equal.

Syntheses of 1,2-cycloheptanedione by the selenium dioxide oxidation of cycloheptanone and of 1,2-cycloheptanedionedioxime by oximation of the dione that both gave high yields of product are described. Methods are presented for the macro- and micro-gravimetric analyses of nickel, including nickel in steel, based on the use of this water-soluble *vic*-dioxime as the precipitant. This reagent, capable of precipitating nickel(II) ions from solutions containing large quantities of iron(III) ions complexed with tartrate or citrate, was found to possess almost all the good characteristics of both 2,3-butanedionedioxime and 1,2-cyclohexanedionedioxime without their disadvantages. Platinum interfered with the gravimetric determination of palladium with 1,2-cycloheptanedionedioxime.

The Stoll, Hulstkamp and Rouvé method for the preparation of cyclodecan-1- α 1-2-one was successfully carried out. Two methods were employed for the oxidation of this acyloin to the dione. A procedure for the oximation of this compound to 1,2-cyclodecanedionedioxime was devised. This reagent, insoluble in water, exhibited

no value as an analytical reagent for nickel(II) or palladium(II) ions.

1,2-Cyclohexanedionedioxime- d_2 , 1,2-cycloheptanedionedioxime- d_2 and 2,3-butanedionedioxime- d_2 , as well as their nickel(II) derivatives, have been prepared. The infrared absorption spectra of these compounds, together with those of the parent *vic*-dioximes and their nickel(II) and palladium(II) derivatives, in Nujol mulls (range 2 to 26 microns) and perfluorokerosene mulls (range 2 to 7 microns) were obtained by means of a Baird recording infrared spectrophotometer.

The infrared spectra of the *vic*-dioximes and deuterio derivatives are considered, with particular emphasis on the positions of the O-H and O-D absorption maxima. The absence of O-H or O-D absorption maxima in the wave length regions usually attributed to the fundamental vibration frequencies of these atomic pairs in the various nickel(II) and palladium(II) inner-complex compounds is discussed. A comparison is made between the spectra of 3 pairs of nickel(II) inner-complex compounds which differ only by the substitution of deuterium for hydrogen.

Arguments are presented for the possibility of an atomic arrangement of 1,2-bis(*vic*-dioximo- N,N')nickel(II) compounds in which the oxime hydrogens are located midway between the 2 oxygen atoms. An O-H-O structure in these inner-complex compounds in which the oxygen to oxygen distance is less than 2.5 Å, is postulated. A search of the literature revealed that this is the first report of an O-H-O structure in which the oxygen to oxygen distance is less than that observed in normal hydrogen bonding.

INFLUENCE OF HOST TEMPERATURE AND PATHOGEN VARIABILITY UPON SPREAD OF *PHYTOPHTHORA INFESTANS*¹

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Spread of *Phytophthora infestans* under field conditions is influenced by aerial dispersal of the spores, host temperature, and variability of the pathogen. Aerial dispersal of the spores results in a scatter around the primary point of dispersal. The assumption was made that random and uncorrelated movements of spores in three dimensions results in "normal" distributions of spore concentrations with variances that are functions of the distance from the source. Consequently, spore deposition was expressed as a function of distance from the source, X ; number of spores released, Q ; and proportion of spores settling out, p . If the proportion of host leaves diseased, D , is linearly proportional to the number of spores deposited, then

$$D = \frac{0.14 p Q e^{-6.8pX^{1/8}}}{k X^{15/8}}$$

where k is the constant of proportionality. This hypothesis was substantiated by comparing it to the distributions of diseased leaflets around three "point" sources of *P. infestans* spores in 1949 and 1950 in Iowa and Indiana. The results suggest that the above hypothesis will permit the prediction of the form of disease gradients surrounding point sources of inoculum.

Primary infection surrounding the three sources of *Phytophthora infestans* was limited to the lower leaflets with less than 0.1 per cent of the leaflets beyond 5 yards from the source diseased. As secondary infection progressed, an increasing number of upper leaflets were infected and

the steepness of the disease gradient decreased until equal numbers of upper and lower leaflets were infected and a zero gradient was produced.

Temperatures of potato and tomato stems and leaves influence the spread of *P. infestans*. Predictions of leaf and stem temperatures from considerations of energy exchanges of the plants were verified by field observations with 30 gauge copper-constantan thermocouples threaded into the plants. Leaves exposed perpendicular to insolation were about 6°F. warmer than leaves exposed parallel to insolation. Sunlit leaves near the top and bottom of a tomato plant were 14° and 22°F. warmer, respectively, than sheltered leaves. Upper exposed leaves were about 10° and 1°F. warmer on clear and cloudy days, respectively, and 2° and 1°F. cooler on clear and cloudy nights, respectively, than lower sheltered leaves. Upper leaves were about 10°F warmer on a clear day and 2°F. cooler on a cloudy day than temperatures observed in a conventional instrument shelter. Consequently, during clear weather dew is expected to condense earlier in the evening and evaporate earlier in the morning from exposed leaves than instrument shelter observations indicate. Differences between leaf and air temperatures tended to decrease as wind speed increased. No temperature differences were observed between potato and tomato leaves or between tomato leaves in open and closed plantings if the leaves were similarly exposed.

Temperatures of roots and stems depart from the temperatures of their soil and air environments because the thermal conductivity of the plant is greater than that of the soil. Shaded and sunlit stems at the soil line were 10° and 20°F. cooler, respectively, than the soil line during the day. At night a stem at the soil line was 3°F. warmer than the soil line.

Pathogenic variability of *Phytophthora infestans* on tomato and potato hosts was defined by expressing quantity of disease as a linear function of main effects and interactions of four factors: host, pathogen, environment, and time. Other pathological characteristics of the four factors, e.g., host

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- b. Doctoral Thesis No. 1168. Submitted June 4, 1951.
- 2 a. B. S., University of Chicago, Chicago, Illinois, 1946.
M.S., Iowa State College, Ames, Iowa, 1949.
- b. Fellow, Agricultural Experiment Station.

resistance, were defined also in terms of effects or interactions. The defining effects and interactions were estimated from observed facts, and, consequently, the corresponding pathological characteristics were precisely evaluated. For disease observations averaged over environments and times the function became:

$$y_{ij} = m + h_i + p_j + (hp)_{ij}$$

where y_{ij} is the ij^{th} disease observation, m the mean, h_i effect of the i^{th} host (resistance), and $(hp)_{ij}$ manifestation of pathogenic races or, more precisely, variants (hp). Manifestation of variants (hp) depends upon hosts as well as pathogens.

Similarly, variants (pn), which are discriminated by differential environments, were defined in terms of $(pn)_{jk}$ which is the interaction of pathogen and environment. Environments, for example, could be humidities or fungicides. Variants (pt), which are discriminated by differential rates of development, were defined in terms of $(pt)_{jm}$ which is the interaction of pathogen and time. These precise definitions are applicable in many problems in pathology.

Different environments and times of

observation when plants were inoculated in the greenhouse affected the manifestation of variants (hp), the so-called potato and tomato races of *Phytophthora infestans*. Variants (hp) were discriminated more easily when the plants were inoculated with sporangial rather than zoosporeal suspensions or when observations were made 232 rather than 112 hours after inoculation. Variants (hp) were discriminated with equal ease whether the plants remained in the moist chamber 10 or 20 hours. Two variants (hp) were discriminated in twelve isolates of *Phytophthora infestans* from potato and tomato plants from eastern and north-central United States. The "tomato" variant (hp) was severely pathogenic upon both tomato and potato. This variant (hp) was most often isolated from tomato but was isolated also from potato. The "potato" variant (hp) was severely pathogenic upon potato but not tomato. This variant (hp) was most often isolated from potato but was isolated also from tomato. The variants (hp) were also variants (pt) because on tomato the development of the tomato variant (hp) continued while the development of the potato variant (hp) ceased after 5 days. Reproduction of the potato variant (hp) tended to fail on the tomato host.

POPULATION DYNAMICS OF THE MEARN'S COTTONTAIL

(*SYLVILAGUS FLORIDANUS MEARN'SII* ALLEN)

IN THE IOWA STATE COLLEGE ORCHARD AND ARBORETUM¹

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Iowa harvests between one and two million cottontails yearly, the largest number of any game species in Iowa. In recognition of this importance, Project 568, "Studies With the Cottontail Rabbit," was initiated by Dr. George O. Hendrickson at the inception of the Cooperative Wildlife Research Unit at Iowa State College in 1935. This present work under Project

568 was carried out under the direction of Dr. Hendrickson, Associate Professor of Zoology at Iowa State College.

Fluctuations and their causes in cottontail rabbit (*Sylvilagus floridanus mearn'sii* Allen) populations were studied in the vicinity of Ames, Iowa, during 25 months, from June, 1948 to August, 1950. A continuous live-trapping and tagging program was carried out in the 18 months from October 1, 1948 to April 1, 1950 in 78 acres of the College Orchard and Arboretum. With a maximum of 67 live traps of the box-type, 283 cottontails were tagged.

The study area, divided into eight sub-areas, was mapped to a scale of 40 feet to the inch with contours and vegetation shown in detail. The sub-areas were di-

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vided into cover types and the plant species of each cover type were listed with their estimated percentage of the vegetation available to cottontails. Changes in population numbers and movements of populations were described in reference to vegetation, weather, activities of man, predation and other influences.

Methods used in the field and in handling the data are described. These concern trapping and ear-tagging cottontails, hunting for nests, analysing vegetation and computing census data from trapping records. A series of population formulas and a graphic method for their solution are presented.

Estimates of the population numbers in each of the eight sub-areas for the 18-month trapping period are shown on graphs, by sex and age groups. A rapid ingress of cottontails took place in the fall of each year, 47 in 1948 and 40 in 1949. At the same time the population was subject to heavy losses. This ingress started in the first period with temperatures above 32°F. following the first killing frost each year.

In the week of January 10-16 of both years, the cottontail population became relatively stabilized with 0.30 cottontails to the acre in 1949 and 0.44 cottontails to the acre in 1950 in the first five sub-areas. The 42 per cent increase was primarily the result of uprooting 9.2 acres of old seedling apple trees and leaving them in windrows through the fall and winter of 1949-50. This over-wintering population was augmented in the spring by cottontails from near-by farm buildings. A breeding population of nine males and 22 females was estimated present in the week of June 13-19, 1949, an adult population density of 0.40 cottontails to the acre in the 78 acres.

In the spring and summer quarters, two peak population estimates coincided with the peaks of two nesting periods. The peak estimated population in the first nesting period came in the week of June 13-19, 1949, with 1.79 cottontails to the acre estimated. In the second nesting period the peak came in the week of September 12-18, with 1.91 cottontails to the acre estimated. Prior to September 31, 43 per cent of all juveniles produced in the area were estimated lost.

Computations using "trap-nights" were found to involve serious errors and were used in this study only to demonstrate the sources of error.

Tabulated by cover types for each month are the number of cottontails trapped, the average number of times

each was caught and the percentage of the entire catch for each sub-area. The number of animals trapped to the acre is also given for some cover types. The number of cottontails known to have been in a given unit of cover in a certain period of time is taken as the best single measure of cover use. The numbers of cottontails making use of cover types and segments of cover were found to be in direct proportion to the density of the available vegetation as determined by visual estimates, except as the use of cover was modified by its location with respect to other cover. In general, cover consisting of bluegrass and shrubs or low branches of trees was the most dense and the most used. Almost the entire population was concentrated in such cover in the fall and winter. In general, that part of the juvenile population using the best cover was predominantly female.

In the 45.7 acres of the trapping area designated for nesting study, 19 nests were found after the young had left them. Twenty-two litters were estimated to have emerged from nests in the area. Seven nests judged to have been unsuccessful were also found. From the measurements of trapped cottontails, the average hind foot length of a cottontail newly emerged from the nest was estimated to be 4.5 cm. The average growth rate was estimated to be 0.7 mm. per day or 5.0 mm. per week, up to about 64 days of age, when the hind foot averaged about 9.0 cm. No sound basis was found for estimating the age of cottontails more than 64 days old. Emergence dates were calculated for each juvenile with a hind foot measurement of 9.0 cm. or less, and these animals were assigned to litter numbers by matching emergence dates and locations in which trapped.

Two nesting periods were evident in the study area, one from April 27 to July 11 and the other from September 3 to 30. In the first period, 15 litters were estimated to have emerged in the study area. In the second period, five litters were estimated to have emerged. Two other litters were estimated to have emerged in the interval between these periods. A ratio of two successful nests to one unsuccessful nest to the adult female was estimated.

Evidence is presented to support the hypothesis that young cottontails usually scatter independently in random directions on leaving the nest and that they do not usually re-enter the nest or re-assemble as a family group.

The more severe winter and greater

snow depth in 1948-49 resulted in much heavier use of browse than the more mild winter and lighter snow cover of 1949-50.

Hunting by dogs was estimated to be the most important decimating influence

in the study area. Hunting by man was the only other such influence of importance. No evidence of serious disease was found. Several cases of infection, infestation and injury are described.

CHEMICAL PROPERTIES OF URANIUM HYDRIDE¹

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There are only two references to uranium hydride in the chemical literature prior to the existence of the Manhattan Project. The first of these gave no valuable information; the second was a patent issued in 1931 of a general method of preparing metal hydrides. The reaction of hydrogen with the electrolytic uranium available at that time was found to take place above 200°, and a crude dissociation pressure-temperature curve was given. No chemical or other physical properties were presented.

The intensive investigations of uranium hydride on the Manhattan Project began early in 1943, when it was found that massive uranium metal of high purity, available for the first time, reacted with hydrogen at 250° forming a black, pyrophoric powder. By thermal decomposition of the hydride finely divided and exceedingly reactive uranium was produced. This powdered metal reacted rapidly with hydrogen even at room temperature, with considerable heat being generated. Uranium hydride was also found to be produced by the action of steam on uranium at 250°, and by the action of tetralin or decalin on uranium, reactions which also yielded naphthalene. Deuterium was observed to react with uranium at 250°, forming uranium deuteride.

Analysis of uranium hydride by combustion and weighing the water formed, by weight gain on formation, and by weight loss on decomposition, showed that there were 2.97 hydrogen atoms for every uranium atom. It was demonstrated that the ratio of hydrogen to uranium

atoms in the hydride, counting only the uranium not combined with the impurities originally present in the metal (carbon, iron, oxygen, etc.), was 3.00, making the formula of uranium hydride UH_3 .

The physical and thermodynamic properties of uranium hydride were summarized. Formed at atmospheric pressure, the hydride particles easily passed through a 400 mesh sieve, but formed at high pressures, the product consisted of much larger fibrous crystals. X-ray diffraction analysis disclosed the crystal structure of UH_3 as cubic, totally unrelated to the structure of the metal, which is orthorhombic. The unit cell of the hydride, containing eight molecules, was found to be 6.631 Å on edge, corresponding to an X-ray density of 10.92 ± 0.01 g./cc. The respective figures for uranium deuteride were 6.620 Å and 11.11 ± 0.01 g./cc. The particle densities of uranium hydride and deuteride, measured by the use of a helium densitometer, were 10.95 ± 0.1 and 11.20 ± 0.1 g./cc., while the bulk density was about 3.4 g./cc. A series of measurements of the densities of U-UH_3 and U-UD_3 mixtures, as a function of the composition, showed that the relationship was linear within the limits of experimental error. This established that the systems were either two-phase systems (U and UH_3 phases or U and UD_3 phases) or perfect solid solutions. X-ray analysis showed that the hydride could not be a solid solution, and was in all probability a true chemical compound.

Pressure-composition isotherms for uranium hydride had a steep rise at the uranium side to a long horizontal section representing a constant pressure. The curves corresponding to formation of the hydride then rose rapidly on the uranium side, but the curves corresponding to decomposition contained a pronounced dip at about 98 mole per cent hydride, just after the horizontal, constant pressure

1 a. Chairman of Committee, J. A. Wilkinson, Professor, Dept. of Chemistry, Industrial Science Research Institute.

b. Doctoral Thesis No. 819. Submitted December 13, 1946.

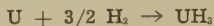
2 a. B.S., University of Tulsa, Tulsa, Oklahoma, 1939.

b. Associate Chemist, Institute for Atomic Research.

section. An explanation for this unexpected dip is lacking. It was found that hydrogen did not transfer from the hydride to the powdered metal in a system maintained at 325°. Dissociation pressure-temperature studies showed that the Clausius-Clapeyron equation was obeyed. The pressure for the deuteride was always about 1.4 times that of the hydride. The equations for the dissociation pressures (in mm.) as a function of temperature were:

$$\begin{array}{ll} \text{Hydride} & \log p = \frac{-4500}{T} + 9.28 \\ \text{Deuteride} & \log p = \frac{-4500}{T} + 9.43 \end{array}$$

Calculations based on the above data using the van't Hoff reaction isochore showed that the heat of the reaction



was $\Delta H = -30.8$ kg.-cal. Direct measurement gave $\Delta H = -30.5$ kg.-cal. Attempts to separate deuterium from hydrogen employing the hydride reaction were fruitless.

It was found impossible to preferentially leach the fission products from uranium hydride prepared from metal previously subjected to deutron bombardment in the cyclotron. Gaseous fission products did not escape on conversion to hydride.

The chemical properties of the hydride were investigated in some detail. Although pyrophoric, the hydride could be rendered air-stable by gradual exposure to air, which caused partial oxidation. Although nitrogen and carbon dioxide had little effect at room temperature, the hydride, once ignited, continued to burn in these gases. Added gradually, water caused the evolution of some heat, but had little other effect; addition in a large amount at a time caused deflagration. The non-oxidizing acids when diluted very slowly dissolved the hydride, but hot, concentrated sulfuric acid was reduced. Nitric acid, or acidified oxidizing agents such as hydrogen peroxide, dissolved the hydride forming uranyl salts. Organic solvents were without effect, except for the chlorinated hydrocarbons, which were decomposed, sometimes with violence. The more soluble silver salts reacted smoothly with uranium hydride, liberating silver metal in a spongy form; the perchlorate ion of silver perchlorate was also reduced, yielding silver chloride. Other heavy metal salts reacted with the hydride as well.

It was observed that the various halogen-bearing gases reacted with the hydride, generally at 250°, yielding uranium halides in fine, conveniently-handled powders. Thus hydrogen fluoride gave uranium tetrafluoride, hydrogen chloride gave uranium trichloride, and hydrogen bromide gave the tribromide; the latter two halides were oxidized by chlorine and bromine vapor to the respective tetrahalides. Steam reacted with the hydride yielding uranium dioxide, hydrogen sulfide gave uranium disulfide, ammonia gave a nitride, and phosphine gave the sesqui-phosphide, U_2P_3 . These reactions served admirably as preparative methods. By the use of uranium hydride and certain compounds readily prepared from it, thorough purification of several common laboratory gases was achieved. Hydrogen chloride, for example, was freed of moisture, oxygen, and chlorine by passing over heated uranium trichloride. The rare gases could be rigorously purified by passing over powdered uranium at 700°; hydrogen or deuterium could be similarly treated, or could be generated by thermal decomposition of the hydride or deuteride.

Attempts were made to reduce organic compounds with uranium hydride. Although reactions occurred, none of the expected products could be isolated.

By mixing uranium hydride intimately with uranium tetrafluoride and heating to 1,100°, the hydride was decomposed, and the uranium liberated reduced the tetrafluoride to uranium trifluoride, previously unknown. The trifluoride was a dense black, coke-like solid. X-ray analysis showed that its crystal structure was hexagonal, with two UF_3 molecules per unit cell, with $a = 4.13$ Å and $c = 7.33$ Å. Heating above 1,600° caused disproportionation into uranium and uranium tetrafluoride, the latter of which sublimed away.

The evidence quite strongly suggested that uranium hydride is a salt-like hydride, in the same class as sodium and calcium hydrides, rather than an interstitial compound, as is the case with palladium hydride.

Uranium hydride formed what appeared to be solutions in mercury. These were termed "amalgams," although they were probably not true solutions, since mercury nearly free of uranium could be separated by centrifugal filtration, and since amalgamation of uranium hydride containing radioxenon (from the disintegration of a fission product) did not cause the liberation of this gas. The amalgams varied in consistency from a

fluid through a semi-solid to a gray powder with increasing hydride concentrations, and some of them had a remarkable tendency to adhere to glass, forming a mirror. The hydride was found to be precipitated from its amalgam by the action of air, water vapor, or hydrogen sulfide. The product so obtained had an H/U ratio considerably lower than three, showing partial attack by the air, water, or hydrogen sulfide. The amalgams were most probably colloidal suspensions.

Uranium hydride and the hydride reaction proved to have a number of practical applications. These included: laboratory source and reservoir of pure hydrogen and deuterium, preparation of powdered uranium, preparation of uranium compounds, isolation of intermetallic compounds of uranium, etching of metallographic specimens, maintaining a given hydrogen or deuterium pressure, and analysis of metallic uranium for the free element.

WINTER BEHAVIOR AND SPRING DISPERSAL OF THE RING-NECKED PHEASANT (*PHASIANUS COLCHICUS TORQUATUS* *Gmelin*) IN EMMET COUNTY, IOWA¹

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The purpose of this study was to contribute information on the winter behavior and spring dispersal of ring-necked pheasants so that the more efficient management of this species in Iowa might be possible. With this in mind, the study revolved around two major objectives which were: (1) to study the behavior of pheasants on sites that maintain winter pheasant concentrations, and (2) to study the dispersal of these birds from such sites in the spring. Consequently the investigation was divided into two main phases, the winter and the spring periods. During the former phase, activities were concentrated on intensive trapping and banding of pheasants. Lesser winter activities involved censusing and a study of cover relationships and field behavior. In the spring phase, activity centered on following the dispersal movements of pheasants from two winter concentration areas.

Data obtained in this investigation were secured in the Estherville Area, which includes north-central Emmet County, Iowa, and adjacent south-central Martin County, Minnesota. Within this general area, two sites known for winter concentrations of pheasants, Birge Lake and Grass Lake Game Areas, were chosen for intensive

observation. Field observation consumed approximately 2,760 hours from February 14 through August 9, 1948, from January through June 4, 1949, and from January 5 through May 27, 1950.

Trapping was undertaken in order to mark pheasants for subsequent study of their movements. Pheasants were marked for identifying purposes with two leg bands and painted tail feathers.

A year to year increase was recorded in the maximum number of pheasants wintering on Grass Lake and on 39 sections of surrounding farm land. The maximum winter population observed at Grass Lake ranged from 170 in 1948 to 420 in 1949, and finally, 522 in 1950. A count of 120 on Birge Lake in 1948 increased to 240 in 1949, but dropped to 192 in 1950. The observed sex ratio in the field during these three years ranged between 37.6-50.0 males to 100 females.

Snow affected the winter pheasant concentrations, for significant correlations of "r" = .96 (.01 level = .87) during the 1947-48 winter and "r" = .73 (.01 level = .64) during the 1948-49 winter were found between the number of birds recorded on Grass Lake and the depth of snow on the ground.

Birge and Grass lakes with their variety of vegetative cover helped fill the need for winter pheasant cover in the Estherville Area. The most heavily utilized types of cover present were giant ragweed, river bulrush, green ash, white and peachleaf willows, and cottonwoods. Farm shelterbelts were most frequently relied on by

- 1 a. Chairman of Committee, Edward L. Kozicky, Associate Professor, Dept. of Zoology and Entomology.
- b. Doctoral Thesis No. 1104. Submitted August 21, 1950.
- 2 a. A.B., San Diego State College, San Diego, California, 1943.
- M.A., University of California, Berkeley, California, 1947.
- b. Fellow, Agricultural Experiment Station.

the pheasants for winter cover off Birge and Grass lakes. Cover along fencerows, road ditches, and drainage ditches was less often utilized.

Pheasant activity during the winter months was restricted during periods when winds measured more than 10 to 12 miles per hour. Except in extreme cases, weather did not seem to affect the time of feeding as much as it did the routes followed to and from the feed and the type of food utilized.

Trapping was conducted on Birge and Grass lakes during each of the three winter periods covered in this investigation. The most successful trap sites were located in stands of mixed giant ragweed and green ash and in a small stand of young white willows.

During 1948, 50 pheasants were captured, including 44 new birds and 6 repeats. In 1949, 537 were trapped, including 395 new birds, 140 repeats, and 2 returns from 1948. In 1950, 599 birds were trapped, of which 384 were new birds, 174 were repeats, and 41 were returns, 39 from 1949 and 2 from 1948.

Weights of 378 pheasants (79 cocks and 299 hens) were recorded during the 1949 trapping season and 425 (90 cocks and 335 hens) during 1950. Mean weights for cocks were 50.3 ounces in 1949 and 48.3 in 1950. Mean weights for hens were 36.3 ounces in 1949 and 37.1 in 1950.

Three consecutive trappings of pheasant populations wintering on Birge Lake and Grass Lake Game Areas indicated a survival of banded birds represented by the series of $100 - 7.4 - 0.7$. The shrinkage or turnover rate of banded birds on the areas between winters was found to be from 91 to 92 per cent.

Data were gathered on various spring phases of ring-necked pheasant behavior, including widespread crowing by cocks, display by cocks before hens, cock fighting, and winter flock breakup, as well as gregariousness and flock composition. These various phases first appeared from one to two weeks later in 1950 than in 1948 and 1949. Growth of spring vegetation was similarly delayed.

Winter flock breakup began during the first half of March in each year of this study. Widespread, frequent crowing by cocks first appeared in 1948 between March 13 and 19. It was recorded between March 20-26 in 1949 and March 27-April 2 in 1950. Active antagonism between cocks and active displaying by cocks in front of hens were observed first in 1948 and 1949 between March 13 and 19, in 1950 between March 20 and 26.

The chief source for data on winter and spring movements of pheasants was the appearance of marked birds away from Birge and Grass lakes. During 1948, 44 birds were banded and released for study. Since 311 of the 397 pheasants marked in 1949 and 371 of the 425 marked during 1950 were trapped and released at Grass Lake, that area developed into the center of study of movement.

During the 1949 winter period, all but one of 21 marked birds observed off Birge and Grass lakes were within 1.0 miles of those areas. The mean distance traveled by 19 pheasants out from Grass Lake was 0.52 miles. One hundred and forty-one marked birds observed off the two areas during the winter of 1950 were all within 1.0 miles of the areas except for one cock seen 2.16 miles from Grass Lake. Mean distance traveled by 139 birds from Grass Lake was 0.46 miles.

Each year during the spring period, from 70 to 83 per cent of the birds wintering on Birge and Grass lakes dispersed on to the surrounding farm land.

The first dispersal movements were recorded early in March of each year of this investigation. Main dispersal was underway between March 13 and 19 in 1948, and between March 20 and 26 in 1949 and 1950. The peak of dispersal movements was reached during the week of April 3-9 in 1949 but in mid-April in 1950. The last week in April brought main dispersal movements to a conclusion in 1949, while May 10 brought a general termination to the 1950 movements.

A high statistical correlation was found between the distance traveled by the pheasants in dispersal and the time of year. The "r" value during 1949 was .96, .01 level = .80; during 1950, .94, .01 level = .76.

The greatest observed radius of spring dispersal from Grass Lake was the same for both sexes during 1949, 7.0 miles. During 1950, no movement was recorded over 4.3 miles.

Forty-six marked birds moved a mean distance of 0.43 miles from Grass Lake in March 1949. The mean for 146 observations in March 1950 was 0.55 miles. Means for 96 records and 123 records gathered during the peak of dispersal in April of each year were 1.00 miles in 1949 and 0.98 in 1950.

A statistical comparison of the means for data gathered in May of each year at the conclusion of spring movements out from Grass Lake found each year's dispersal comparable. During 1949, 80 examples had a mean of 1.39 miles; during 1950, 47 had a mean of 1.40 miles.

Each spring, aside from minor exceptions, pheasants dispersed no more than 4.5 to 5.0 miles out on the farm land surrounding Birge and Grass lakes.

The observed number of pheasants that remained to nest on Birge and Grass lakes each year showed little change even though observed maximum winter populations showed pronounced increases. An-

nual nesting populations at Birge Lake varied between 39 in 1948 and 44 in 1950. The population at Grass Lake varied from 72 in 1948 to 92 in 1950. Observed nesting populations on 39 sections surrounding Birge and Grass lakes varied from 12 to 35 birds per section, with means of 20.1 per section in 1948, 22.4 in 1949, and 22.5 in 1950.

THE EFFECTIVENESS OF A DECELERATED COURSE IN GENERAL CHEMISTRY¹

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This study, made at the Iowa State College, deals with 1,156 general chemistry students who were making unsatisfactory progress at mid-term. These students were enrolled in chemistry beginning in the Fall of 1944 up to and including the Fall of 1947. Of the 1,156 students, 710 elected to change to a decelerated course which required two terms for the work usually completed in one. The remainder continued in the regular course.

In August of 1949, two academic years after the last of these students enrolled in general chemistry, records of these students were checked to determine the relative effectiveness of the two courses. Division was made into two groups. Students were placed in the survival group who had (1) graduated, (2) were in school, (3) had transferred or dropped with a grade point average of two or above. The attrition group included those not in college as of August, 1949, having withdrawn with a grade point average of less than two.

Of the decelerated group 40.42 per cent were in the survival group, whereas, of the regular group, 28.92 per cent were in the survival group. On treatment with chi square, the decelerated group showed a highly significant advantage in terms of survival.

College entrance test scores and high school averages were collected whenever available for all students in the study. The Iowa State College Mathematics Placement Test scores were discarded since this test was not required of Agri-

culture and Home Economics students and it seemed desirable to retain these students in the study. Those test scores considered further were (1) The American Council on Education Psychological Examination, of which Quantitative and Linguistic scores were recorded in addition to the total score, and (2) The United States Armed Forces Institute—Correctness and Effectiveness of Expansion scores.

The main statistical treatment was arbitrarily limited to those students enrolling in general chemistry in the Fall terms of 1946 and 1947 who were deficient at mid-term. This group consisted of 422 decelerated students and 162 students from the regular course.

Students deficient at mid-term had the option of remaining in the regular course or electing the decelerated course. An analysis was made to ascertain whether this option was a function of a student's ACE, USAFI, and high school average.

Students electing the decelerated course had a higher mean high school average than those remaining in the regular course whereas, with the ACE and USAFI, the reverse was true. The first of these differences was significant at the 1 per cent level and the last two approached but did not meet the usually required 5 per cent level of significance.

For the purpose of using all three variables in a battery for distinguishing course option, a discriminant function was developed which produced a highly significant distinguishing power for the discriminant function. As a result of the foregoing analysis, no subsequent analysis has been undertaken without controlling upon student ability as reflected by the ACE, USAFI, and high school average.

No significant loss was incurred when the total ACE score was substituted for

1 a. Chairman of Committee, James E. Wert, Professor, Dept. of Vocational Education, Agricultural Experiment Station.
b. Doctoral Thesis No. 1112. Submitted September 19, 1950.
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the Quantitative and Linguistic scores used individually, so the total score was used. There remained only three variables upon which the remainder of the study was based: ACE, USAFI, and high school averages.

A discriminant function, using ACE, USAFI, and high school averages was developed for the prediction of survival-attrition of students deficient at mid-term for the total group, for the group in the regular course only, and for the group in the decelerated course only.

Multiple biserial R's were computed for the three relationships and found to be .4180, .3598, and .4506, for the total group, regular group, and decelerated group, respectively. These correlations compare favorably with multiple correlations obtained for predicting general achievement, particularly within homogeneous groups such as deficient students.

An analysis was made to ascertain the possibility of eliminating a variable from each of the three foregoing discriminant functions. It was found that none could be eliminated without significant loss when dealing with the total group or with the decelerated group. With the regular group, however, the ACE, USAFI, and high school averages would not predict

survival-attrition significantly better than the high school average alone.

The relative effectiveness of the regular and the decelerated courses for students deficient in chemistry at mid-term was evaluated in terms of survival-attrition. The proportions surviving were 0.39506 for the regular course and 0.4692 for the decelerated course.

Before testing the significance of this difference, control of student ability by the discriminant function for all deficient students was used for the purpose of eliminating possible bias as well as for rendering more sensitive the test of significance.

It was found that the removal of bias changed the proportions surviving to .3899 and .4672 for the regular and decelerated courses, respectively, when equated on student ability as here evaluated.

When the difference in proportions surviving was tested for significance a *t*-value of 2.15 was found, much greater than that required for sufficient proof.

It was concluded, therefore, that the decelerated course is more satisfactory than the regular course in general chemistry for students deficient at mid-term when evaluated in terms of survival-attrition.

MONOGRAPH OF THE COCCINELLIDAE (COLEOPTERA) OF THE UPPER MISSISSIPPI BASIN¹

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The Coccinellidae inhabiting the Upper Mississippi Basin of the United States, a region embracing the states of Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, and Kansas and Nebraska east of the one hundredth meridian, number some 115 species and subspecies. These are contained in 33 genera of the 8 tribes of the subfamily Coccinellinae, and in one genus of the subfamily Epilachninae. The Coccinellidae are commonly known as lady beetles and, with two exceptions, are predacious insects of considerable importance in the

biological control of pests of farm and garden crops. The present study is chiefly taxonomic in nature, although biological data are included when available.

In assembling collection records and data for the monograph, all of the major insect collections in the area were visited and studied. In addition, where certain groups needed revisionary measures, the types of the species in these groups were studied.

The usual practice of including specimens showing minor variations in color pattern as species or named varieties is not followed. This results in the number of named forms in the family being reduced rather than increased, as is usual in a monographic study of a group. In some cases, where sufficient material or records of previous workers were available, subspeciation is indicated and so designated.

1 a. Chairman of Committee, H. H. Knight, Professor, Dept. of Zoology and Entomology.

b. Doctoral Thesis No. 1150. Submitted March 8, 1951.

2 a. A.B., Southwest Missouri State Teachers College, Springfield, Missouri, 1936. M.A., University of Missouri, Columbia, Missouri, 1939.

b. Fellow, Dept. of Zoology and Entomology.

In the tribe Hyperaspini Costa 22 species are recorded in the genus *Hyperaspis* Redtenbacher, 3 species recorded in the genus *Hyperaspidius* Crotch, and 5 species in the genus *Brachyacantha* Chevrolat. The number of species and varieties in *Brachyacantha* Chevrolat is substantially reduced by including color variants as synonyms of old and well-established species.

The tribe Scymnini Costa, containing the genera *Stethorus* Weise, *Scymnus* Kugelann, *Cephaloscymnus* Crotch, *Cryptolaemus* Mulsant, and *Nephaspis* Casey, contains 41 species in the region studied. Considerable revisionary work is done in the genus *Scymnus* Kugelann. The subgenus *Pullus* Mulsant of the genus *Scymnus* Kug. is thoroughly revised using the male genitalia as the basis for establishing species. Of the 24 species treated in the subgenus *Pullus* Muls., 8 are described as new. Male genitalia of the species in this group are illustrated by photographs.

The range of *Cryptolaemus montrouzieri* Mulsant, a species originally introduced from the South Pacific area into the United States in California over fifty years ago, is extended to the states of Indiana and Missouri. The nature of the collection data indicate that this species may enter the middle western states in shipments of fruits, although the species may be established in this region.

The genus *Nephaspis* Casey is listed as occurring in North America for the first time. The description of new species of *Nephaspis* Csy. from Iowa is presented

with illustrations of the male genitalia.

The species in the remaining tribes and genera are not radically changed from the status assigned by previous workers in the field, except that species named from specimens showing minor variation of color pattern are included as synonyms in many cases. This is especially true in the case of the genus *Adalia* Mulsant in which six perviously named species and varieties are included under two species which are well established by genetic investigation by previous workers and by investigation of male genital characters in the present work.

Two species of the genus *Cycloneda* Crotch, *sanguinea* (L.) and *munda* (Say), are recognized as occurring in the Upper Mississippi Basin. No previous study of the genus has ever illustrated valid characters for the separation of these two species. The male and female genitalia, either of which can be used to separate the two species, are figured. The range of both species is defined.

Identification keys for the ready identification of tribes, genera, and species of the Coccinellidae of the Upper Mississippi Basin are included. Each species is accompanied by a description and the known distribution of the species is given for each state in the region.

Eight plates containing fifty figures accompany the text. These figures illustrate the male genital characters of the species of *Brachyacantha* Chev., *Hyperaspidius* Cr., *Scymnus* Kug., *Nephaspis* Csy., and *Cycloneda* Cr.

CONDUCTANCES, TRANSFERENCE NUMBERS, AND ACTIVITY COEFFICIENTS OF CHLORIDES OF SOME HIGH ATOMIC NUMBER RARE EARTHS IN AQUEOUS SOLUTION¹

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The conductances, transference numbers, and activity coefficients of lanthanum

chloride, samaric chloride, europic chloride, and ytterbic chloride were determined in order to test the present theories of electrolytic solutions as well as to make available accurate data on these useful properties for the above rare earth chlorides.

The Jones bridge and its accessories were employed to measure the conductances over a concentration range of 0.0007 N. to 0.1 N. The moving-boundary

1 a. Chairman of Committee, Frank H. Spedding, Professor, Dept. of Chemistry, Director of the Institute for Atomic Research, Industrial Science Research Institute.

b. Doctoral Thesis No. 1148. Submitted March 6, 1951.

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b. Associate Chemist, Institute for Atomic Research.

method was used to determine the transference numbers of the cations from concentrations of 0.007 N. to 0.1 N. A simply constructed transference cell is described along with an electronically controlled constant current apparatus. A hollow stop-cock was employed to form the junction between the indicator solution and the investigated solution in the transference cell. Concentration cells with transference were employed to measure the mean molal activity coefficients over a concentration range of 0.003 N. to 0.1 N. The junctions between the solutions were formed by a cell similar in design to that of the transference number cell.

The data on all of the above properties were estimated to have an accuracy of within 0.1 per cent. The exact composition of the solutions was the limiting error in the determinations.

The infinite dilution values for the equivalent conductances, the cation conductances, and the cation transference numbers were calculated for the four rare earth chlorides from the data obtained in the equivalent conductance determinations. The values for each of these properties were found to fall in the order: lanthanum chloride > samaric chloride > europic chloride > ytterbic chloride. The radii of the ions of these four rare earths, as determined by X-ray crystallographic methods, decrease in the same order. Since a small ion should encounter less resistance in traversing a solution and, thus, be more conducting than a large ion, it appears that the radii of the hydrated ions must be such that $\text{Yb}^{3+} > \text{Eu}^{3+} > \text{Sm}^{3+} > \text{La}^{3+}$. Hence, the rare earth ions possess different degrees of hydration and the order of hydration is: $\text{Yb}^{3+} > \text{Eu}^{3+} > \text{Sm}^{3+} > \text{La}^{3+}$.

The equivalent conductances for each

in the same definite order. The order of deviation was: $\text{YbCl}_3 > \text{EuCl}_3 > \text{SmCl}_3 > \text{LaCl}_3$, and may represent a measure of the tendency of the rare earths toward ionic association under the influence of Coulombic forces, or it may be related to the different degrees of hydration.

The data on the cation transference numbers of the four rare earth chlorides did not agree with the Onsager treatment in the concentration range studied in this thesis. This fact is surprising since the conductance measurements were in agreement with the limiting Onsager slope. Other authors have found that, in general, polyvalent ions show this same anomaly. No satisfactory explanation can be offered for this discrepancy although it is hoped that when the data on all of the rare earths becomes available some explanation will become apparent. In view of the results obtained in the conductance measurements the rare earth transference numbers would be expected to be arranged in the order: $\text{La}^{3+} > \text{Sm}^{3+} > \text{Eu}^{3+} > \text{Y}^{3+}$. However, it was found that the cation transference numbers for samarium chloride are slightly greater in value than those found for lanthanum chloride. This can not be explained.

The activity coefficients agreed with the Debye-Hückel theory throughout the concentration range studied, that is, for concentrations up to 0.1 N. The activity coefficients for the chlorides of lanthanum, samarium, and europium were extended to concentrations of 2 molal by fitting the data of Robinson and Mason to those obtained in this thesis. Since the Debye-Hückel equation is not expected to be valid over such a wide range of concentrations due to the assumptions made in its derivation, attempts were made to fit these data to empirical equations of the type:

$$\log \gamma \pm = - \frac{A \sqrt{C}}{1 + a^0 B \sqrt{C}} + B'c + Dc \log c$$

of the rare earth chlorides were in agreement with the Onsager theory for concentrations up to about 0.0025 N.; however, there was a small, but definite, difference in the concentration at which each rare earth chloride began to deviate from theory. Further, at higher concentrations, the deviation of each rare earth chloride from the theoretical slope became greater

in which B' and D are constants of no known theoretical significance; however, no values for B' and D were found which would accurately describe the data over the concentration range from 0 to 2 molal. The values found in the Debye-Hückel theory for the mean distance of closest approach of the ions, a^0 indicate that the rare earth ions and chloride ions are separated by one molecule of water.

PREDICTION OF PROBATIONARY FRESHMEN AND EFFECTIVENESS OF A SUPPLEMENTARY COUNSELING PROGRAM AT DRAKE UNIVERSITY¹

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One of the most disturbing factors noted upon examination of Drake University enrollment records was the high student mortality, especially among freshman groups. This mortality results from the withdrawal of large numbers of students due to their inability to adjust to college life. This study is confined to one area of difficulty, that is, the scholastic problem which undoubtedly represents a large portion of such situations encountered by students. More specifically, this study is confined to the freshman probation group. It would seem that a favorable approach to the solution of this problem may be developed through a supplemented counseling program.

It was assumed that fewer students would be placed on probation if effective counseling could reach the student long before he was placed on probation. The need for some method by which potential probation students could be designated, is clearly seen. Data available in the Admission Office and Testing Bureau at Drake University were used to develop an effective, predictive scheme.

This predictive scheme must then be put to its best use in preparation for the most desirable counseling.

Complete data were available for 666 freshmen from the 1948 class. The data available for each of the students were as follows: test scores on A.C.E., Nelson-Denny Reading Test, the Kuder Preference Record, and the high school percentile rank. The discriminant function was used to give maximum separation between the probation and non-probation groups so that identification of an individual with a group was more reliable. Using the scores on the two parts of A.C.E., the two sections of the Nelson-Denny Reading

Test, six of the nine Interest Scores, and the high school percentile rank gave 11 independent variables to consider. For the Commerce students, the score of American Institute of Accountant's Orientation Test was used as an additional variable.

Of the 666 students with complete data, 187 were from the College of Commerce and Finance. Preliminary work was done first to determine if the Interest Scores from the Kuder Preference Record would make a significant contribution to a discriminant function formed. It was concluded that they made no significant contribution and could be eliminated from further consideration. A discriminant function was formed from the six remaining variables. Variables were deleted and the losses were tested until only two variables remained, X_2 , linguistic score on the A.C.E., and X_7 , high school achievement. The discriminant function actually used for prediction of probationary students in the College of Commerce was $V = X_2 + 1.142696X_7$. As a measure of the relationship between probation tendency and these two variables, a multiple biserial R was computed and found to be 0.6797.

The same procedure was followed to obtain a discriminant function based on the 234 students from Liberal Arts College. Again, after a preliminary analysis, the Kuder Interest Scores were dropped from further consideration. A discriminant function with the five remaining independent variables was then determined. Variables were deleted and the losses were tested until again only two variables remained, X_1 , Paragraph Reading Comprehension of the Nelson-Denny Test, and, as before, X_7 . $V = X_1 + 1.152049X_7$ was the discriminant function used for Liberal Arts College. A multiple biserial R of 0.6693 was found between probation tendency and the two variables.

Since the number of students involved from the College of Education and the College of Fine Arts respectively was too small on which to base a discriminant

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b. Doctoral Thesis No. 1108. Submitted August 22, 1950.

2 a. B.S., University of Minnesota, Minneapolis, Minnesota, 1935.
M.A., *ibid.*, 1939.

function, the predicted probationary students for these colleges were obtained from an all-university discriminant function. Following the foregoing procedure, the equation of the discriminant function finally used was $V = X_1 + 1.037029X_2$. A multiple biserial R of 0.6237 was obtained.

All three of these multiple biserial R 's seemed to indicate a fair degree of success in predicting probationary students. To determine which of the 476 freshmen were potential probationary students, V scores were computed for each of them using the appropriate discriminant function. The predicted probation list of 114 students consisted of 36 students from Commerce College, 50 from College of Liberal Arts, 14 from College of Education, and 14 from College of Fine Arts. Of the 114 students, 68, or 60 per cent, were on probation or withdrew from the university at the end of the first semester. In addition to the 53 predicted students there were 33 other freshman students also on probation at the end of the first semester. Thus, of the 86 freshmen placed on probation, 53, or 62 per cent, had been predicted as such.

Naturally there are many other factors, such as social maladjustment, too many hours of outside work, or poor study habits, which will affect a student's academic achievement. The use of the discriminant function was an attempt to use variables which were available before a student began his college experience to predict probation tendency.

Within each college, students from the predicted probationary group were selected at random to form experimental and control groups. The students in the control group were exposed to the ordinary counseling while the experimental group received supplemental counseling.

Five criteria available for the evaluation of the effectiveness of the counseling were: (1) average marks for the first semester, (2) average marks for the school year, (3) successful-unsuccessful status at the end of the first semester, (4) successful-unsuccessful status at the end of the school year, and (5) survivor-mortality status at the end of the school year.

For purposes of analysis, the Colleges of Commerce and Liberal Arts were treated separately; the Colleges of Educa-

tion and Fine Arts were combined; and an all-university group was formed combining all colleges.

Under the hypothesis that the experimental and control groups were random samples from the same population, a t test was used to determine if differences in average marks between groups were significant.

At the end of the first semester, significant differences were found between groups for the all-university combination and for the College of Education and College of Fine Arts combination. Again, at the end of the year, significant differences between groups were obtained for the same combinations.

If a student had been placed on probation or had withdrawn from the university he was designated as unsuccessful. All others were classified as successful. Four cell contingency tables were formed by classifying the students according to the two characteristics, experimental-control and successful-unsuccessful. Under the assumption that the two characteristics were independent, chi-square tests were performed. At the end of the first semester there was some evidence to indicate a difference between the experimental and control groups for the all-university combination. At the end of the year, significant differences were indicated between groups for the all-university and College of Education and College of Fine Arts combinations.

For the final evaluation, a student was classified as a mortality if he withdrew from the university or had been dropped from the university by his dean for low academic standing. All others were designated as survivors. A four cell contingency table was formed and a significant value of chi square, 4.060, was obtained. It was concluded that there was a significant difference between the experimental and control groups with respect to mortality.

In summary, all of the evidence indicates that the supplemented counseling was beneficial to this incipient, probationary group. It would seem wise to include all such students under the extended, counseling program. If this were done, student mortality due to scholastic achievement might be appreciably decreased.

STREAMING ORIENTATION OF AMYLOSE AND AMYLOSE COMPLEXES¹

DONALD ZUCKER²

Department of Chemistry

There are several methods available for determining the molecular weight of amylose, the straight chain component of starch. All are interfered with by one or more of the following: presence of amylopectin, aggregation, degradation, side reactions, incomplete reactions, non-rigidity or unknown structure of the molecules. It was the object of this investigation to find ways of eliminating these interferences in the case of the streaming orientation of amylose and amylose complexes.

A considerable part of the work was done with the iodine complex, eight amylose preparations and one whole starch being investigated in this way. Measurement of the orientation angle was accomplished by using the property of dichroism exhibited by the amylose-iodine complex. These samples did not display the sharp minima usually found in birefringence studies, and the positions of the maxima, also determined, were even more uncertain. Visual observation of the samples was therefore not adequate for location of positions of maximum and minimum intensity of the transmitted light.

A photoelectric apparatus was built for this purpose. A multiplier phototube was used, its output being A.C. since the mercury arc light source was modulated at 120 cycles. The output was amplified by a preamplifier and a tuned A.C. amplifier which discriminated against undesired signals. After rectification, part of the signal was opposed by a variable known D.C. voltage, and the unopposed signal was amplified and registered on an output meter. The characteristics of this apparatus were determined.

Aqueous KOH was tried as the solvent for the amylose, the alkali being neutralized with HCl before the iodine was added.

The KCl present after neutralization caused the complex to aggregate, and this method was rejected. Hot water alone was not satisfactory as a solvent, even with autoclaving.

Aqueous pyridine was then tried as the solvent, 15 per cent by volume being the concentration finally decided on as best for the amylose samples available. When this solvent was used, evidence was found that the complexes were molecular in nature. Not only were the amyloses apparently disaggregated by the solvent, but they remained so after being complexed with iodine, and were especially stable after glycerol was added to increase the viscosity of the solvent.

Amylopectin did not form a complex with iodine under the conditions finally adopted, and did not interfere at all with the results obtained from amylose, even when the amylopectin constituted 95 per cent of the total carbohydrate of the sample. It was therefore possible to investigate amylose in whole starch without first separating it from the amylopectin. This was a major advantage over all other methods used.

Empirical length distributions for most samples were found which yielded theoretical results for the orientation angles in excellent agreement with the actual values. Where investigated, these empirical length distributions also gave theoretical results for the magnitude of the dichroism which agreed well with the actual values. The length distribution equations found indicated that a large part of the amyloses consisted of molecules of less than 100 glucose units. However, theoretical considerations showed that such molecules would have no effect on the streaming orientation results, and since solubility would be expected to eliminate the shorter molecules during the various processes of preparation, there was no way to know from the data available whether there were short molecules present or not. It was therefore not possible to determine an average degree of polymerization, but it was probably of the order of 200-400 glucose units per molecule. This was considerably less than half the values obtained for

1 a. Chairman of Committee, Joseph F. Foster, Assistant Professor, Dept. of Chemistry, Agricultural Experiment Station.

b. Doctoral Thesis No. 1094. Submitted July 15, 1950.

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M.S., Iowa State College, Ames, Iowa, 1940.

b. Graduate Assistant, Agricultural Experiment Station.

these samples by viscosity and osmotic pressure.

Since the same empirical-length distributions agreed with both the experimentally-determined orientation angles and the magnitude of dichroism, the calculated value for the dichroism per molecule was essentially constant at all gradients used. This indicated a molecule of constant length; that is, a rigid molecule. Since the structure of the complex in the solid state is known, and there is reason to believe it is the same in solution, molecular weights could be determined from the lengths found by streaming orientation.

All of the above results were obtained with solutions containing only about 0.002 per cent amylose. The low concentration was very desirable, since it reduced the probability of molecular interactions.

Approximately twelve uncomplexed amyloses were investigated in ethylenediamine-glycerol solutions, using birefringence as a means of measuring the extent

and angle of orientation. The effects of amylopectin and of amylose concentration were studied. The presence of amylopectin was found to give length values much too long at low gradients. Too high concentrations of amylose (over 1 per cent) were also found to give greater lengths, but at all gradients.

Lengths obtained for the uncomplexed amyloses were somewhat longer than the lengths of the corresponding complexes at the same flow gradients. The increased lengths were especially pronounced at high gradients, indicating a possibility that the uncomplexed amyloses were non-rigid and became longer at higher gradients. The value of the average absolute birefringence of the molecules increased more at moderate and high gradients than one would predict from the estimated polydispersity of the preparations, also indicating elongation. This is in agreement with previous evidence obtained by a study of the intrinsic viscosities of a number of amylose preparations.

MASTERS' THESES

Accepted September 1, 1950—June 30, 1951*

The titles of theses are arranged in alphabetical order by names of authors. Each listing includes the name of the author, the title of the theses and the department.

- Abate, Louis John. Sublimation of zirconium tetrafluoride. Chemical Engineering.
- Anderson, Robert Frederick. Some operating characteristics of injection nozzles. Mechanical Engineering.
- Armstrong, Escar Weldon. Structural geology of an area in northeastern Fremont County, Colorado. Geology.
- Armstrong, Ray Ernest. Test of modification of parts of whirlwind terracer. Agricultural Engineering.
- Augustson, Richard Norman. Constitution diagram of the copper-zirconium alloy system. Chemical Engineering.
- Ayala, Erique. Growth promoting and inhibiting properties of dried juice of alfalfa in a simple vegetable diet for chicks. Poultry Nutrition.
- Baer, John Larry. Equilibrium measurements in the adsorption separation of hafnium and zirconium. Chemical Engineering.
- Bailey, Merritt Elton, Jr. Analysis of consumer motivation techniques employed by the Iowa State College Press. Technical Journalism-Economics.
- Ball, Aldon Gordon. Expectations in the agricultural firm. Agricultural Economics.
- Barclay, William Dell. Validity of t-test in randomized experiments. Statistics.
- Bard, John C. Changes in tenderness, fiber cohesiveness, and moisture content of canned beef due to thermal processing. Food Technology-Animal Husbandry.
- Benecke, Robert Oscar. Analysis of the industrial accident reporting system in the state of Iowa. Industrial Engineering.
- Bernhardt, Frank Leon. Recovery and identification of insect fragments from cream style corn. Horticulture-Entomology.
- Berry, Keith David. Micropaleontological zonation of the Niobrara formation, El Paso County, Colorado. Geology.
- Bishop, Glenn Raymond. Vibrational characteristics of non-uniform curved cantilever beams. Mechanical Engineering.
- Bittinger, Morton Wayne. Water supply, equipment, and labor requirements for irrigation of Iowa field crops. Agricultural Engineering.
- Blake, Joseph Thomas. The effect of method of administration on the absorption and storage of vitamin A by dairy calves. Dairy Husbandry.
- Boeke, Robert William. Proposed techniques for controlling running waste of a publishing company. Industrial Engineering.
- Boldt, Wilbur John. Production of the mourning dove, *Zenaidura macroura* (L), in Shelterbelts, Stutsman County, North Dakota, 1950. Wildlife Management.
- Bonnicksen, LeRoy Wayne. Effectiveness of clips, staples and cement as fasteners for asphalt-shingle tabs. Agricultural Engineering.
- Bottoms, Albert Maitland. The kinetics and mechanism of the oxidation of sulfite by ferric ion. Physical Chemistry.
- Brandt, Albert Johnson. The use of matrix notation for transfer functions of physical systems. Mathematics.
- Bressani, Ricardo. Effect of environmental factors and genotype on carotene and protein content of selected forage crops. Crop Production.
- Brown, Robert Grover. An electrostatic function generator. Electrical Engineering.
- Brown, William Stuart. Activity coefficients of aqueous methanol solutions. Physical Chemistry.
- Bulman, Cornelius. Preservation effect of various concentrations of curing salts in comminuted pork. Food Technology-Bacteriology.
- Bureau, Alfred Joseph. Deposition of electrically conducting stannic oxide coatings on ceramic surfaces. Physics.
- Butler, Thomas Arthur. Methods of preparing spectrographically pure praseodymium salts. Physical Chemistry.
- Callen, Max William. A method of reducing the bandwidth of speech transmission. Electrical Engineering.
- Cameron, John Ross. Genetic and age effects on immunization to fowl typhoid, *Salmonella gallinarum*. Genetics.
- Camery, Morgan Peter. Effects of simulated hail injury on soybeans and corn. Crop Production.

*A list of Masters' theses accepted July 1, 1950—August 31, 1950 is included in No. 2, Vol. 25 of the Iowa State College Journal of Science.

- Campbell, Ted. Relationships between psychological test scores and ratings of sales managers. *Industrial Psychology*.
- Carlander, Harriet Bell. A history of fish and fishing in the upper Mississippi River. *Economic History*.
- Carman, Grant Mowat. Litter size as it affects resistance to *Salmonella typhimurium* in an inbred line of mice. *Genetics*.
- Ching, Clifton Buchanan. Progeny performance and fertility of selected clones of *Bromus inermis* Leyss. *Crop Breeding*.
- Choudhury, Fazal Ahmed. Stabilization of a clay soil from Appanoose County for highway purposes. *Highway Engineering*.
- Collins, Robert Matthew. Research in agricultural education for advanced degrees at the Iowa State College. *Agricultural Education*.
- Connors, Helen Elizabeth. Field plot techniques for sweet potatoes obtained from uniformity trial data. *Statistics*.
- Crane, Paul Levi. Fertility in tomatoes with special reference to tetraploidy. *Genetics*.
- Crothers, Edna McNeil. Effect of storage at room temperature and 0°F. upon certain fruit jellies. *Institution Management*.
- Das, Bidhan Chandra. Morphological basis for low fertility in Autotetraploid sweet clover, *Melilotus alba*. *Crop Breeding-Plant Morphology*.
- Deatherage, John Foster. Application of local sands to cold mix sand-asphalt paving mixtures. *Highway Engineering*.
- Densmore, Barbara Edith. Initial permanent oxidation of wool fiber. *Textiles and Clothing*.
- DeVries, Leonard Lyle. Performance and operating costs of tile trenching machines. *Agricultural Engineering*.
- Dewell, Edgar Harrison. Zirconium ions in aqueous solution. *Physical Chemistry*.
- Domanovsky, Paul. Application of multiple beam interferometry to the study of a supersonic air jet. *Physics*.
- Dumenil, Lloyd Carver. Residual effect of nitrogen fertilizers applied to corn on the yields of the following crops. *Soil Fertility*.
- English, Thomas Saunders. Growth studies of the carp, *Cyprinus carpio* Linnaeus, in Clear Lake, Iowa. *Economic Zoology*.
- Erickson, James George. Age and growth of the black and white crappies, *Pomoxis micro-maculatus* (Le Sueur) and *Pomoxis annularis* Rafinesque, in Clear Lake, Iowa. *Fishery Management*.
- Ferguson, Dale Louis. Analysis of skewed rigid frames and arches. *Structural Engineering*.
- Fluhr, Frederick Robert. Equivalent circuit of a gated-beam vacuum tube. *Electrical Engineering*.
- Froeschner, Richard Charles. Monograph of the Orthoptera of Iowa. *Entomology*.
- Fryxell, Paul Arnold. Locule number inheritance in tomatoes. *Genetics*.
- Fungal, Henry P. Yeast fermentations of corn fractions. *Food Technology*.
- Gardner, Wayne Howard. Accuracy of metering rectifier-type loads with conventional watt-hour meters. *Electrical Engineering*.
- Gardner, Wilford Robert. Determination of soil moisture by neutron scattering. *Physics-Soil Physics*.
- Gasser, William Robert. Temperature duration relationships for selected Iowa meteorological stations. *Agricultural Climatology*.
- Gee, Yu Heng. Distribution of web and flexural strains in a post-stressed concrete trussed beam. *Structural Engineering*.
- Ghostly, Frederick James. Comparative performance of pure strains, strain crosses and breed crosses in poultry. *Poultry Breeding*.
- Gibbens, John Monett. Cost relationships in cash grain farming. *Agricultural Economics*.
- Goldman, Alan Stewart. An appraisal of methods used in conducting a consumer survey. *Agricultural Economics*.
- Goleman, Denzil Lyle. Insect pests of red clover in central Iowa in 1950. *Entomology*.
- Goreau, Theodore Nelson. Organotin compounds containing functional groups. *Organic Chemistry*.
- Graff, Richard Stanley. Application of economic lot quantity theory to a specific tire manufacturing company. *Industrial Engineering-Industrial Economics*.
- Graham, Dee McDonald. Bacteriophage retention by cultures of lactic streptococci. *Dairy Bacteriology*.
- Grahn, Douglas. Genetic implications of internal organ weight differences in inbred mice. *Genetics*.
- Green, Henry Burwell. Some experiments in peach insect control. *Entomology*.
- Greene, William Arthur. Radiographic demonstration of circulatory (arterial) variations in isolated bovine female internal genitalia. *Veterinary Obstetrics*.
- Grimes, Dale Mills. A comparison of the temperature characteristics of copper oxide and selenium rectifiers from 0°C. to -185°C. *Physics*.
- Grimsal, Edward George, Jr. Structure of ferroelectric barium titanate. *Physics*.
- Grissom, Dale B. Heritability and association of characters affecting popping volume in dent-popcorn crosses. *Crop Breeding*.
- Guy, Harold Paul. Level terrace design as affected by hydrologic factors. *Agricultural Engineering*.
- Guzman, Matilde de la Paz. Acceptability of pressure-canned snap beans and sweet corn versus subtilin-treated products processed with mild heat. *Foods*.

- Haq, Muhammad Shamsul. Motion pictures as a means of disseminating agricultural information in East Pakistan. Technical Journalism.
- Harper, Ralph Samuel. Some measured personality traits of accident-prone industrial workers. Industrial Psychology.
- Hendrix, Lois May. Children's conceptual reactions to certain restrictions imposed in the nursery school. Child Development.
- Henriksen, Gerald Marius. Efficiency of a capillary washer in removing beryllium oxide dust. Mechanical Engineering.
- Ho, Paak Sui. Nutritive requirements of growing and fattening pigs. Animal Production.
- Hobart, Oscar F., Jr. Fungicidal control of leaf-spot and mildew on nursery cherry trees in Iowa. Plant Pathology.
- Hodges, Teddy Omar. Lap requirements of corrugated aluminum roofing as affected by roof slopes. Agricultural Engineering.
- Hogan, Frank Earl. Analysis of continuous frames in space. Structural Engineering.
- Howard, Addison Merle. Pellet technique of spectrographic analyses: determination of common impurities in zirconium metal. Physical Chemistry.
- Hughes, William Lewis. Feasibility of crystal control in television sweep circuits. Electrical Engineering.
- Hurwicz, Henry. Movement of the isothermal surfaces in the sterilization process of beef in cans. Mechanical Engineering.
- Hutchinson, Marjorie Ruth. Comparison of sodium acid pyrophosphate baking powder as leavening agents in plain cake for institution food service. Institution Management.
- Irving, Evelyn Berry. Factors related to acceptance of foods by pupils in certain Iowa schools. Home Economics Education.
- Jacobs, Alfred. Development of a process for the production of a high hafnium concentrate. Chemical Engineering.
- Jensen, James Lee. An electric analogue for hydraulic network analysis. Electrical Engineering.
- Johnson, Elliott Benjamin. Allocation of various street services to street widths. Municipal Engineering.
- Johnson, Gordon Keith. Conduction of heat through composite walls. Mathematics.
- Johnson, Howard Paul. Seepage through loessal earth dams. Agricultural Engineering.
- Kegley, Kathryn Alice. Factors influencing the educational plans of graduate students in Home Economics Education at Iowa State College. Home Economics Education.
- Keough, Myrtle Doralin. Trends in adult vocational homemaking education in Iowa from 1938-1950. Home Economics Education.
- Kester, Lloyd Trostle. Water-insoluble acids in butter and cream. Dairy Bacteriology.
- King, Douglas Malcolm. Relationship between cost of living index and convictions for certain offenses in Canada. Sociology.
- Klopfenstein, Ralph Walter. Low frequency waves in certain types of transmission lines. Applied Mathematics.
- Knaphus, George. Vertical distribution of *Pythium graminicola* in soil. Plant Pathology.
- Knepper, Hilda Leona. Conceptions of a group of kindergarten children of the father's role in the family. Child Development.
- Kohlman, Eleanor Louise. Problems in child care reported by high school girls in Iowa rural towns. Home Economics Education.
- Kristensen, Erik. Analysis of basic research procedure in farm management. Agriculture Economics.
- Kunze, Otto Robert. Resistance of sheet aluminum to rupture by the heads of various types of roofing nails. Agricultural Engineering.
- Lagerstrom, John Emil. A synthesizing circuit for symmetrical component currents. Electrical Engineering.
- Lamouria, Lloyd Henry. Design and performance of a pilot plant dehydrator for agricultural products. Agricultural Engineering.
- Limburg, Henry Homer. Prediction of achievement in the engineering machine design sequence courses at Iowa State College. Vocational Education.
- McConnell, Richard Duncan. A survey of the development of church architecture in Iowa prior to 1900. Architectural Engineering.
- McDonald, Ernest Duncan. Interrelationships and relative variability among *S.* and open-pollinated progeny of selected bromegrass clones. Crop Breeding.
- McGinnis, William Joseph. Preparation of rare earth metals. Inorganic Chemistry.
- Madsen, Frode. Diacetyl production by *Leuconostoc citrovorum* in simplified media. Dairy Bacteriology.
- Magsanoc, Baldomera Montemayor. Factors related to interest in children shown by girls in Iowa rural towns. Home Economics Education.
- Mangold, Robert Edward. Fall and winter losses of the eastern Bob-white, *Colinus v. virginianus* L., on the Decatur County Quail research area, 1949-1950. Economic Zoology.
- Matis, Eleanor Louise. Cochran's method for comparing scales of measurement: techniques and applications. Statistics.
- Meier, Dorla Arlene. Factors concerning personal problems of high school students. Vocational Education.

- Miller, Gilbert Edwin. Some components of mechanical comprehension. Applied Psychology.
- Moses, Alfred James. Radioactivities produced by photo nuclear reactions of wolfram. Physical Chemistry.
- Neild, Ralph Eugene. Distribution and movement of isotopic nitrogen N^{15} in corn plants. Soil Fertility.
- Norris, George Hutchinson. Economics of permanent pasture improvement. Agricultural Economics.
- Ortmeier, Dale Herbert. Some social correlates of intellectual changes. Psychology.
- Page, Orville Thomas. Host-parasite relationships of common scab on potato tubers. Plant Pathology-Morphology.
- Patel, Kantilal Vallabhbhai. Preparation of superphosphate by treatment of rock phosphate with fluosilicic and sulfuric acids. Chemical Engineering.
- Paul, Donald Lee. Influence of maturity and variety on the methionine and cystine content of sweet corn. Food Technology-Horticulture.
- Peery, Dudley Lewis. Analysis of farm management teaching recommendations for vocational agricultural classes made by farm management workers and successful farmers. Agricultural Economics.
- Peterman, Patricia Ann. Multi-employer pension plans. Industrial Economics.
- Picklum, Warren Eugene. Developmental morphology of the inflorescence and flower of red clover. Plant Morphology.
- Poirier, Rolland Paul. Inheritance of susceptibility to *Lymphomatosis*. Genetics.
- Porterfield, Jay G. Influence of length of cut on harvesting and storing of chopped hay. Agricultural Engineering.
- Potter, Norman. Effects of calcium on proliferation of lactic streptococcus bacteriophage. Dairy Bacteriology.
- Prill, Robert Charles. Effects of current land use on land productivity and crop production. Agricultural Economics.
- Ratner, Robert Alexander. Effect of variation in weight upon move times. Industrial Engineering.
- Rector, Jack Davis. Study of power system stability by the use of an electrical analogue. Electrical Engineering.
- Robbins, Otis, Jr. The productivity of the ring-necked pheasant, *Phasianus colchicus torquatus* (Gmelin), in Washington County, Iowa, 1950. Wildlife Management.
- Rojas, Basilio Alfonso. Analysis of a group of experiments on combining ability in corn. Statistics.
- Royer, Ruth LaVerne. Partial symmetry of linear transformations. Mathematics.
- Ruff, Donald Oliver. Beat-frequency method for measurement of small capacitance. Electrical Engineering.
- Ruhr, Clifford Eugene. Fish population of a mining pit lake, Marion County, Iowa. Economic Zoology.
- Rygg, Paul Theodore. A representation of a finite Boolean algebra. Mathematics.
- Sanford, John Raymond. Analysis of the multivibrator type oscillator. Electrical Engineering.
- Schreiner, Keith Marshall. Productivity of the Wood duck, *Aix sponsa*, (L.), aided by artificial nesting boxes. Wildlife Management.
- Schrier, Joanne Elizabeth. An experimental study of the origin of the parathyroid and thymus glands in the chick. Embryology.
- Schrimper, Richard Johnson. The problem of estimating the number of cattle on feed in Iowa. Statistics.
- Schwink, Thomas Michael. Trematoda of the Bluegill, *Lepomis macrochirus macrochirus Rafinesque*. Zoology.
- Seymour, Keith Goldin. Nitrate distribution and movement in the soil as a measure of the seasonal carry-over of nitrogen fertilizer. Soil Management.
- Sharp, Eugene Lester. Lyophilization of Uredospores of *Puccinia coronata* Corda. Plant Pathology.
- Sherman, Ethel Cromwell. Relationship of Kuder preference record scores to differential college achievement. Applied Psychology.
- Shinn, Allen George. Growth of boron single crystals. Physics.
- Sinner, Robert Dale. Storage of ammonia by means of adsorbing or thickening agents. Chemical Engineering.
- Smith, Frank Orvil. Evaluation of insecticides and fungicides for apple spraying. Horticulture-Plant Pathology.
- Smith, Herschel Forrest. Some implicit function theorems. Mathematics.
- Soule, David Houghton. Effects of training on driving performance of youthful drivers in Iowa. Industrial Education.
- Speer, Vaughn Curtis. Trace minerals for gestation, lactation and growth of swine. Animal Nutrition.
- Sprain, Wilbur. Forecasting probability of first quarter mortality in general chemistry at Iowa State College. Vocational Education.
- Spruill, Albert Wesley. Public relations activities of North Carolina Negro county extension agents through radio stations and newspapers. Vocational Education.
- Staffeldt, Eugene Edward. Pythium and other fungi colonizing sterilized straw in the soil. Plant Pathology.
- Stein, Philip Rayburn. Pre-emergence spraying for weed control. Plant Physiology.
- Stinson, Edgar Erwin. Mechanism of the elimination of hydrogen bromide from ethyl beta-bromopropionate. Organic Chemistry.
- Stoner, William Joseph. Roche's theorem and applications. Mathematics.
- Swago, Andrew William. Graphical analysis of a multivibrator circuit. Electrical Engineering.

- Switzer, William Paul, Jr. Incidence, cultivation, morphology, and certain host relationships of a *Trichomonas* sp. (Protozoa: Zoomastigina) occurring in the nasal cavity of swine. Veterinary Pathology.
- Tabb, John Robert. Land value reports by real estate brokers in Iowa, 1941-50. Agricultural Economics.
- Tekse, Lloyd Christopher. Detection of enterotoxin produced by *Staphylococci*. Veterinary Hygiene.
- Terry, Charles Maynard. Examples in point set theory. Mathematics.
- Terry, William Garland. An analysis of the masters' theses in public school administration at Iowa State College. Vocational Education.
- Thompson, Sarane. Electrophoretic and immunological studies on serum proteins of mice genetically differentiated for resistance to *Salmonella typhimurium*. Genetics.
- Titus, Charles Keith. High-ratio frequency divider for television synchronization circuits. Electrical Engineering.
- van der Zant, Wilhelmas Carl. The utilization of corn syrup solids in ice cream, ice milk and sherbet. Dairy Industry.
- Vestal, Grace Trestrail. Potential techniques for raising the standards of living of workers in Tiquisate, Guatemala. Consumption Economics.
- Wassom, Clyde Ervil. Uniformity trial with bromegrass. Crop Breeding.
- Wegener, Mark Henry. Rates of evaporation of water from saturated cloth. Mechanical Engineering.
- Wiesen, John Mark. The design and analysis of experiments involving sensory impressions. Statistics.
- Willardson, Robert Kent. Characteristics of a diamond conduction counter. Physics.
- Winegarden, Margaret Waterland. Physical and histological changes of three connective tissues of beef during healing. Foods.
- Woodworth, Roger Charles. An economic analysis of the use of electrical equipment in farm production. Agricultural Economics.
- Wu, Mei Chuan Chi. Analysis of ascorbic acid, vitamin B₁₂ and folic acid action in tyrosine metabolism. Physiological and Nutritional Chemistry.
- Wyatt, Andy Jack. Combining ability of five inbred lines of leghorns. Poultry Breeding.

The following summaries and indices may prove helpful to those interested in tabulations and to those who may wish to examine theses in the same or related fields.

1. Masters' theses accepted September 1, 1950—June 30, 1951—173.
 2. Index to masters' theses by departments. The departments are arranged alphabetically. Under each department are listed alphabetically the names of the authors.
- Agricultural Engineering*—10. Armstrong, R. E., Bittinger, Bonnicksen, DeVries, Guy, Hodges, Johnson, H. P., Kunze, Lamouria, Porterfield.
- Agronomy*—12. Bressani, Camery, Ching, Das, Dumenil, Garner, W. R., Gasser, Grisson, McDonald, Neild, Seymour, Wassom.
- Animal Husbandry*—2. Ho, Speer.
- Architectural Engineering*—1. McConnell.
- Bacteriology*—1. Bulman.
- Botany and Plant Pathology*—9. Das, Hobart, Knaphus, Page, Picklum, Sharp, Smith, F. O., Staffeldt, Stein.
- Chemical Engineering*—6. Abate, Augustson, Baer, Jacobs, Patel, Sinner.
- Chemistry*—10. Bottoms, Brown, W. S., Butler, Dewell, Goreau, Howard, McGinnis, Moses, Stinson, Wu.
- Child Development*—2. Hendrix, Knepper.
- Civil Engineering*—6. Choudhury, Deatherage, Ferguson, Gee, Hogan, Johnson, E. B.
- Dairy Husbandry*—1. Blake.
- Dairy Industry*—5. Graham, Kester, Madson, Potter, VanderZant.
- Economics and Sociology*—14. Ball, Bailey, Gibbens, Goldman, Graff, King, Kristensen, Norris, Perry, Peterman, Prill, Tabb, Vestal, Woodworth.
- Electrical Engineering*—12. Brown, R. G., Callen, Fluhr, Gardner, W. H., Hughes, Jensen, Lagershrom, Rector, Ruff, Sanford, Swago, Titus.
- Foods and Nutrition*—2. Guzman, Winegarden.
- Genetics*—7. Cameron, Carman, Crane, Fryxell, Grahn, Poirier, Thompson.
- Geology*—2. Armstrong, E. W., Berry.
- History*—1. Carlander.
- Horticulture*—3. Bernhardt, Paul, Smith, F. O.
- Industrial Engineering*—4. Benecke, Boeke, Graff, Ratner.
- Institutional Management*—2. Crothers, Hutchison.
- Mathematics*—8. Bradt, Johnson, G. K., Klopenstein, Royer, Rygg, Smith, H. F., Stoner, Terry, C. M.
- Mechanical Engineering*—5. Anderson, Bishop, Henriksen, Hurwicz, Wegener.

- Physics* — 7. Bureau, Domanovsky, Gardner, W. R., Grimes, Grimsel, Shinn, Willardson.
Poultry Husbandry — 3. Ayala, Ghostley, Wyatt.
Psychology — 5. Campbell, Harper, Miller, Ortmeyer, Sherman.
Statistics — 6. Barclay, Conners, Matsis, Rojas, Schrimper, Wiesen.
Technical Journalism — 2. Bailey, Haq.
Textiles and Clothing — 1. Densmore.
Veterinary Hygiene — 1. Tekse.
Veterinary Obstetrics — 1. Greene.
Veterinary Pathology — 1. Switzer.
Vocational Education — 12. Collins, Irving, Kegley, Keough, Kohlman, Limburg, Magsanoc, Meier, Soule, Sprain, Spruill, Terry, W. G.
Zoology and Entomology — 13. Bernhardt, Boldt, English, Erickson, Froeschner, Goleman, Green, Mangold, Robbins, Ruhr, Schreiner, Schrier, Schwink.

PUBLICATIONS OF MEMBERS OF THE STAFF OF THE IOWA STATE COLLEGE FOR THE ACADEMIC YEAR 1950-51

Certain summaries and indices are of interest in a survey of the publications of members of the staff of an educational and research institution such as the Iowa State College. The publications are listed in alphabetic order under the names of the senior authors. Junior authors are also listed alphabetically with cross reference to senior author.

SUMMARY

Number of individual staff members listed	460
Number of publications	587
Number of publications with joint authorship	297
Number of publications with single author	290
Number of departments or fields represented in publications	44
Number of research agencies represented in publications	6

INDEX TO PUBLICATIONS BY DEPARTMENTS OR FIELDS

The numbers which follow the names of the departments refer to the index numbers of the alphabetic list by authors

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Agronomy: Total 57 — Numbers 5, 8, 9, 30, 31, 32, 34, 35, 36, 88, 92, 93, 94, 95, 119, 124, 131, 132, 198, 272, 273, 285, 300, 301, 314, 315, 316, 317, 318, 335, 342, 350, 358, 360, 378, 416, 429, 436, 458, 461, 465, 468, 469, 485, 500, 503, 539, 562, 563, 564, 575, 578, 579, 584, 585.	Child Development: Total 1 — Number 239.
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Applied Art: Total 1 — Number 168.	Dairy Industry: Total 10 — Numbers 37, 48, 97, 290, 371, 385, 391, 402, 413, 587.
Bacteriology: Total 20 — Numbers 1, 12, 23, 56, 67, 68, 69, 83, 287, 289, 367, 399, 400, 405, 459, 460, 529, 553, 576, 577.	Economics and Sociology: Total 56 — Numbers 3, 15, 16, 17, 25, 26, 27, 28, 40, 41, 46, 47, 51, 91, 107, 115, 196, 242, 243, 244, 245, 246, 247, 255, 258, 267, 268, 269, 270, 271, 292, 329, 351, 352, 353, 354, 388, 389, 390, 398, 423, 426, 439, 470, 471, 540, 541, 542, 545, 546, 547, 548, 549, 550, 551, 552.
Botany: Total 32 — Numbers 12, 13, 14, 29, 38, 55, 60, 98, 133, 218, 262, 263, 264, 265, 288, 345, 346, 347, 417, 455, 456, 457, 472, 473, 484, 531, 532, 533, 534, 567, 568, 573.	Electrical Engineering: Total 4 — Numbers 50, 434, 451, 557.
Ceramic Engineering: Total 3 — Numbers 139, 237, 238.	Engineering Drawing: Total 1 — Number 169.
Chemical and Mining Engineering: Total 2 — Numbers 10, 11.	English and Speech: Total 3 — Numbers 136, 348, 476.
Chemistry: Total 114 — Numbers 4, 18, 19, 22, 54, 84, 89, 100, 101, 112, 113, 114, 116, 117, 118, 134, 137, 138, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 162, 163, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 209, 210, 211, 229, 230, 231, 232,	Foods and Nutrition: Total 7 — Numbers 21, 128, 129, 208, 412, 437, 530.
	Food Technology: Total 8 — Numbers 21, 126, 127, 128, 129, 208, 412, 437, 530.
	Forestry: Total 2 — Numbers 66, 543.
	Genetics: Total 2 — Numbers 199, 291.
	Geology: Total 16 — Numbers 220, 221, 222, 223, 224, 225, 226, 227, 280, 281, 282, 283, 284, 444, 445, 448.
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- Home Management: Total 6—Numbers 102, 268, 269, 270, 271, 396.
- Horticulture: Total 17—Numbers 1, 61, 62, 83, 109, 110, 141, 170, 331, 332, 394, 395, 431, 553, 554, 555, 571.
- Household Equipment: Total 3—Numbers 123, 279, 412.
- Institutional Management: Total 4—Numbers 20, 21, 85, 506.
- Landscape Architecture: Total 1—Number 140.
- Library: Total 2—Numbers 53, 161.
- Mathematics: Total 9—Numbers 7, 327, 328, 333, 334, 358, 366, 537, 538.
- Mechanical Engineering: Total 4—Numbers 343, 452, 453, 505.
- Modern Languages: Total 1—Number 111.
- Physics: Total 35—Numbers 90, 121, 166, 167, 212, 293, 294, 295, 304, 307, 314, 315, 316, 317, 318, 325, 326, 336, 344, 368, 386, 392, 393, 397, 427, 428, 454, 465, 480, 481, 482, 483, 509, 510, 582.
- Poultry Husbandry: Total 1—Number 122.
- Psychology: Total 10—Numbers 39, 63, 164, 233, 234, 266, 319, 337, 338, 403.
- Statistics: Total 12—Numbers 37, 96, 106, 124, 135, 286, 290, 308, 489, 550, 551, 552.
- Technical Journalism: Total 1—Number 248.
- Textiles and Clothing: Total 2—Numbers 430, 583.
- Theoretical and Applied Mechanics: Total 2—Numbers 174, 387.
- Veterinary Hygiene: Total 1—Number 375.
- Veterinary Medicine: Total 3—Numbers 252, 253, 254.
- Veterinary Physiology and Pharmacology: Total 3—Numbers 302, 303, 410.
- Vocational Education: Total 7—Numbers 2, 103, 104, 105, 239, 259, 260.
- Zoology and Entomology: Total 74—Numbers 24, 33, 43, 44, 45, 49, 52, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 125, 153, 165, 197, 213, 214, 215, 216, 217, 218, 219, 228, 236, 251, 256, 320, 321, 322, 323, 324, 330, 341, 364, 365, 379, 380, 381, 382, 401, 404, 408, 409, 418, 419, 420, 422, 432, 433, 435, 467, 475, 477, 478, 479, 501, 504, 533, 535, 536, 574, 575, 580.

INDEX TO PUBLICATIONS BY RESEARCH INSTITUTES

- Agricultural Experiment Station: Total 252—Numbers 1, 4, 5, 8, 15, 16, 17, 18, 19, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 41, 42, 46, 47, 48, 49, 51, 52, 55, 56, 57, 58, 60, 61, 62, 64, 65, 67, 83, 86, 87, 89, 91, 92, 93, 94, 95, 96, 97, 98, 102, 106, 109, 110, 119, 120, 122, 123, 126, 127, 128, 130, 131, 132, 133, 135, 141, 142, 143, 144, 145, 146, 147, 148, 149, 151, 152, 154, 155, 156, 157, 158, 159, 160, 165, 170, 171, 172, 173, 197, 198, 199, 240, 241, 242, 243, 244, 245, 246, 247, 256, 258, 262, 263, 264, 265, 273, 277, 285, 287, 288, 289, 290, 291, 292, 298, 299, 300, 301, 305, 306, 308, 309, 314, 315, 316, 317, 318, 320, 322, 323, 329, 331, 332, 335, 340, 342, 345, 346, 347, 349, 350, 355, 356, 357, 358, 360, 363, 364, 365, 374, 378, 385, 388, 389, 390, 391, 394, 395, 396, 398, 399, 400, 402, 404, 407, 409, 411, 412, 413, 416, 417, 418, 419, 420, 421, 422, 423, 424, 426, 429, 431, 432, 433, 435, 436, 437, 439, 456, 457, 458, 461, 463, 464, 465, 467, 468, 470, 471, 472, 473, 485, 498, 499, 500, 503, 531, 532, 533, 534, 536, 539, 540, 543, 544, 545, 546, 548, 549, 550, 551, 552, 553, 554, 555, 558, 559, 562, 563, 564, 565, 566, 568, 569, 570, 571, 573, 574, 575, 576, 578, 579, 584, 585, 586, 587.
- Engineering Experiment Station: Total 7—Numbers 238, 296, 297, 487, 493, 494, 572.
- Industrial Science Research Institute: Total 44—Numbers 24, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 113, 125, 147, 150, 153, 166, 167, 304, 341, 372, 373, 379, 380, 381, 382, 386, 401, 408, 409, 446, 447, 454, 475, 501, 504, 535, 561, 577.
- Institute for Atomic Research: Total 70—Numbers 12, 13, 14, 22, 84, 90, 100, 101, 116, 117, 118, 121, 134, 137, 138, 212, 235, 249, 250, 293, 294, 295, 307, 325, 326, 336, 344, 361, 368, 370, 386, 392, 393, 397, 425, 427, 428, 438, 449, 450, 480, 481, 482, 483, 495, 496, 497, 502, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 529, 567, 582.
- Statistical Laboratory: Total 15—Numbers 37, 96, 106, 124, 135, 170, 286, 290, 308, 489, 550, 552, 554, 555, 587.
- Veterinary Research Institute: Total 4—Numbers 261, 414, 415, 466.

INDEX TO OTHER AGENCIES SPONSORING PUBLICATION

- Agricultural and Home Economics Extension Service: Total 16—Numbers 9, 88, 213, 214, 215, 216, 217, 218, 219, 252, 253, 254, 267, 275, 276, 279.
- Engineering Administration: Total 7—Numbers 257, 310, 311, 312, 486, 487, 488.
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